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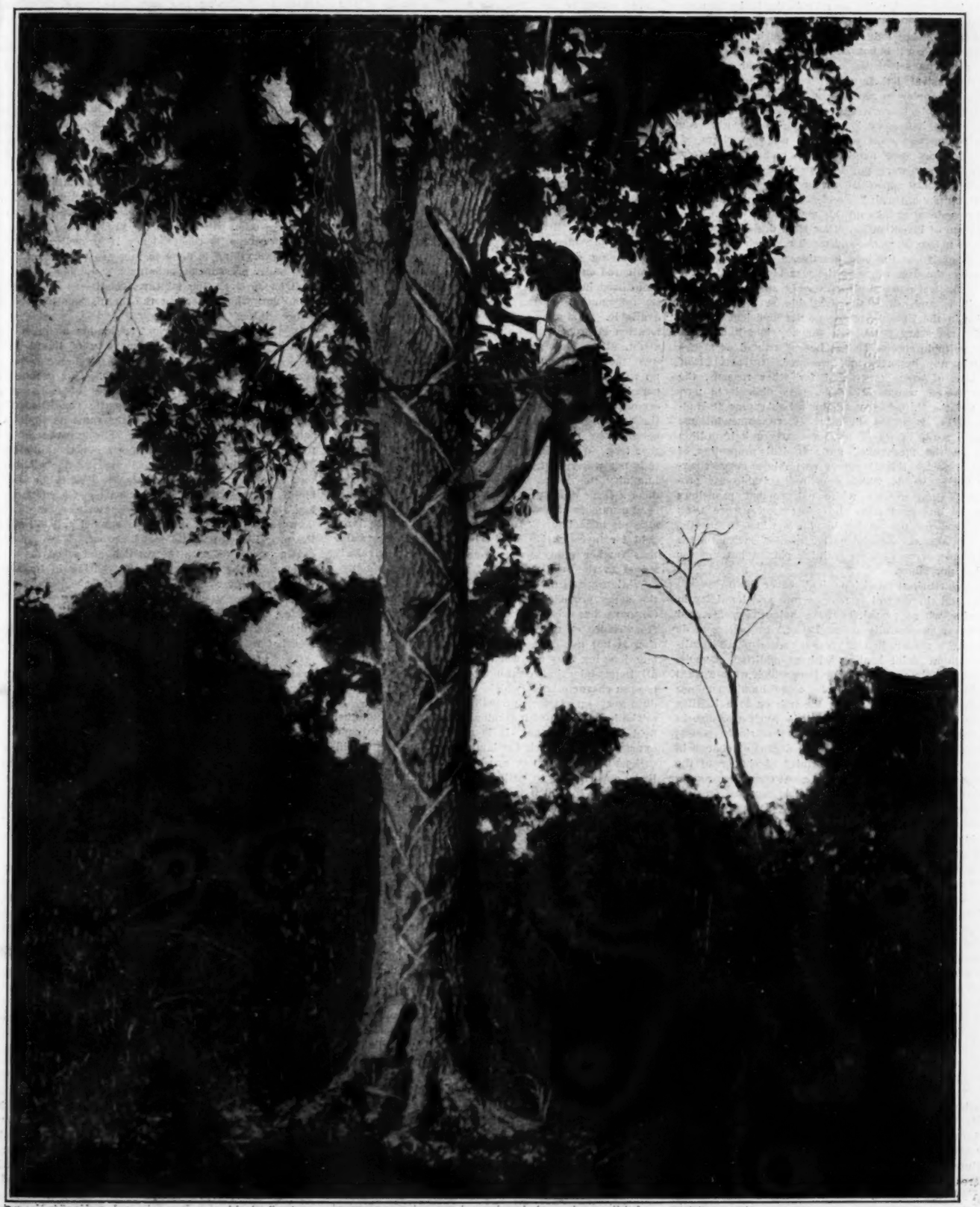

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A typical chiclero bleeding a naseberry tree in British Honduras for the sap from which chicle gum is made. There are 75,000,000 consumers in the United States alone.

GATHERING CHICLE GUM FOR AMERICAN GUM CHEWERS. (See page 172)

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Airplane Propeller Manufacture

Problems Which Have Been or Need To Be Studied

By A. L. Heim, U. S. Forest Products Laboratory, Madison, Wis.*

WHEN the United States entered the war, very little information was available on airplane propellers, the difficulties encountered in their manufacture, and the conditions which they would have to meet in service. However, production was necessary and specifications had to be prepared, using as a basis the little data on hand and the general practices prevailing in the established wood using industries. With such a basis for the specifications it is not surprising that many changes were made as scientific, investigative, and practical tests demonstrated their need.

The first factor to receive consideration was design and fortunately there were available a number of engineers who had some knowledge of this work. An organization was soon established and propellers of many designs were manufactured and tested, after which the best were put into production. Factories were established especially for propeller manufacture, and many piano, furniture, and sash and door factories were remodeled to take up this new line of work.

In lines of investigation other than design, however, we were not so fortunate and much research was necessary to arrive at the best practice.

During the first years of the war black walnut and mahogany were practically the only species used for propellers, and, since the available supply of these species in the United States was not sufficient to keep up the necessary production for any length of time, other suitable species had to be substituted or stocks of mahogany imported and seasoned. On account of the lack of cargo space and for other reasons, the latter course would have been very difficult to pursue, and the U. S. Forest Products Laboratory at Madison, Wis., was appealed to for recommendations. From a study of its records of nearly a half million tests on the mechanical and physical properties of various species, the laboratory was able to suggest several native woods which appeared suitable for propellers. Quarter-sawn white oak combat propellers were put into production and other species were being considered for use on battle planes when the armistice was signed. Several native species, such as birch and maple, were used on training planes, but not for combat propellers.

Manufacturing conditions had never been investigated, and the control of temperature and humidity in factories where propellers were being manufactured was never successfully accomplished. Propellers made during the winter, in the very dry atmosphere resulting from artificial heating without addition of moisture to the air, produced propellers which were certain to absorb moisture during the more humid summer months or when transported through or to a locality where a higher humidity prevailed. Such a change in the moisture content of propellers invariably causes changes in the blade angles. The degree of change in blade angle and the non-uniformity of change of the blades of each propeller may be great enough to render them unfit for service. In fact, it is reported on very good authority that fully 80 per cent. of the propellers manufactured in France were unfit for use when they reached the battle front.

In order to obtain accurate information on certain fundamental factors, the Forest Products Laboratory has under way for the War and Navy Departments a very comprehensive series of tests on full-sized propellers. This investigtion covers a number of factors related to manufacture.

The Laboratory's propeller shop and glue rooms are equipped with apparatus which automatically maintain a constant temperature and humidity. This eliminates any variation in results on account of changes in climatic conditions. After manufacture each propeller is subjected to conditioning treatments in various rooms in each of which a definite climatic condition is reproduced and maintained. All of these rooms have a temperature of 80°F. but the relative humidities in the three rooms now provided are 36, 60 and 90 per cent respectively. Thus each propeller is subjected in rotation to the mean and extreme conditions which it is likely to encounter in service and remains exposed to each condition, being measured, weighed, and carefully inspected at regular intervals, until it reaches equilibrium, upon which it is moved to another condition where the same careful observations and measurements are continued. This work has already demonstrated the desirability of controlling the atmospheric conditions in shops where propellers are being manufactured, and when completed will make possible the drawing of specifications prescribing the allowable range of control.

This series of tests permits accurate study of the effect of moisture content and density of material on the ability of propellers to hold to their original shape during climatic changes, and will determine the proper length of time to store propellers between the time they are roughed out and the carving is finished.

While the work being done at the laboratory will furnish a great deal of fundamental data, there are many other importnt problems which are worthy of careful investigation.

At the present time practically clear stock is required for propeller construction. Not only is such stock expensive and difficult to obtain but much of the stock now discarded might be utilized if the exact effect of certain defects were known. For instance, a small knot is of little detriment in some portions of a propeller provided it is sound and does not disturb the surrounding grain too greatly. Likewise stock now eliminated on account of numerous other defects might be utilized in the construction of propellers if authentic information on the effect of these defects were available. A study of the effect of defects and their location in propellers is very necessary and would, no doubt, allow the use of much material now wasted.

At the present time almost all propellers are made up with hide glue. Only a high grade of this glue is permitted to be used. The glue is inspected by a Government representative at the factory, and if it passes the specification is packed and sealed. It is then accepted by the propeller manufacturer without further test. While this glue gives excellent satisfaction, it is not waterproof, and under extreme conditions of humidity the joints may open. The laboratory has done a large amount of work on glues and has developed a number of new ones which have more or less resistance to moisture. However, there remains a large field for investigation and it is not at all improbable that further study will develop a glue particularly suited to the requirements of propeller manufacture.

While apparently the use of two or more species in the same propeller does not appear reasonable, the Germans have been doing this very thing, whether from choice or necessity, we do not know. Information is not available on the suitability of such combinations but they are worthy of trial and it is not at all impossible that certain species will be found to possess characteristics which, in combination, will produce very satisfactory propellers.

The building up of individual laminations is another field for investigation. It is now permitted, to some extent, to splice stock for laminations, but the specifications in this respect are very strict and there is little opportunity to utilize stock to full advantage. The extent to which it is allowable to piece laminations and the method of joining or splicing must be thoroughly investigated before it will be possible to construct propellers without losing a considerable percentage of good material.

Present-day propellers are practically all made up of laminations about three-quarters of an inch in thickness, and although some variation is allowable, neither the most efficient thickness nor the effect of various thicknesses or combinations of thicknesses on the efficiency of propellers has been determined. While this factor is influenced to a great extent by the available supply of stock, a study of thickness of laminations would be very interesting and there is a possibility that some very important developments might result.

On account of the variation in shrinkage in different directions in timber, there are some species such as oak of which, from all information available, it seems necessary to use only quarter-sawn stock. In mahogany and similar woods where the shrinkages in the radical and tangential directions are very nearly the same, this factor is not so important. However, the degree to which variation from exact quarter-sawing may be allowed in some species is not known. The exact combinations of plain and quarter-sawed material of different species which might be permissible with good service should be studied and the effect of various combinations determined.

While much work has been done and many experiments have been made on various problems in the gluing of propellers, there are many more problems needing investigation. Many specifications call for tooth-planing the glue surfaces, while others do not require it. Some tests on this problem indicate that tooth-planing is of no advantage, and, in certain cases examined, coarse tooth-planing has even been found to give a weaker joint on account of the heavy ridges meeting top to top instead of meshing. Possibly some method of preparing glue surfaces might be devised which would make a stronger joint than that secured with smooth surface.

In the methods of applying pressure and the time and amount of pressure there is a large field for investigation. Some manufacturers use various types of hand clamps, while others use special screw presses, and in practically no case is there any method of measuring the amount of pressure applied. In the time under pressure there is also much variation among manufacturers. While there is no objection to allowing an excessive time under pressure, there is very serious objection to removing the pressure too soon, and this, of course, is the tendency in propeller factories where everything is done to increase production The time under pressure depends upon a number of factors such as species, glue mixture, conditions in the glue room, and whether or not the laminations are heated before gluing.

In the finishing of propeller blades a finish frequently specified consists of one coat of liquid filler, two coats of priming varnish, and three coats of spar varnish rubbed down between coats. This produces a finish which prevents rapid changes of moisture in the propeller, with varying climatic conditions, but the ultimate change is exactly the same as would result without finish of any sort. For purposes of protection during storage or transportation, the aluminum-leaf coating developed at the Forest Products Laboratory is very satisfactory and is the best thing available at the present time. This consists of a covering of leaf aluminum, such as window sign writers use, applied between the coats of varnish or enamel and it renders the propeller practically weatherproof. However, this coating wears off with the varnish, and when the wood is exposed the efficiency of the coating is impaired. Many types of covering have been devised and tested, and still more work should be done along this line to perfect a coating which is weather-proof and easy to apply, and which will withstand considerable abrasion before it fails.

Tips of propellers are now protected with copper, brass, linen, or pig-skin. Metal tips are unsatisfactory in that they must be fastened with screws or rivets and a good bond with the wood is not obtained without a considerable weakening of the tips. The linen and pig-skin tips are glued to the wood and tend to strengthen rather than weaken the propeller, and while they do not withstand wear to the same degree as metal tips, neither are they so heavy and liable to be thrown off. The materials for tipping, the methods of application, and the best shapes of tips will bear considerable investigation and experiment The tips now in use are by no means perfect and could probably be greatly improved by scientific investigation.

There are many other problems which might well be studied and as airplanes become more common, additional problems on propellers will be brought to our attention. Many of the points for investfgation can be handled in a comparatively short time with very simple equipment, while others require a long period of time and very complex and expensive apparatus. With the enormous possibilities of aircraft service, it seems reasonable that all points should be investigated at the earliest possible moment and no expense spared to obtain the information necessary to put propeller production on a firm footing.

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Bibliography of Screw Threads

THE aim of this bibliography is to furnish accounts, as complete as possible, of the various domestic and foreign forms and systems of screw threads together with professional reports relating to actual experience and study. In all, 379 titles are recorded. The value of a list which brings within reach many scattered monographs on this important subject is obvious. An index to authors, titles, subjects and topics is included.—*H. E. Haferkorn.* (*Professional Memoirs Engineer School*, Washington Barracks, vol. x, No. 54, November-December, 1918, Supplement No. 2.)

How a Season Differs from Year to Year*

The Rational Causes of Variations in Our Summers and Winters

By Sir Frederic Stupart, Director of the Meteorological Office, Toronto

A PROBLEM which still remains unsolved in Meteorology is why corresponding seasons in different years differ so much in character. In a previous paper[1] entitled "Is the Climate Changing" the various conditions in nature which lead to the distinctive features of the climatic zone were given as follows:

1. Distance from the equator.
2. Geographical position in relation to land and sea.
3. Altitude.
4. The prevailing winds, the outcome of a general atmospheric circulation.

It was pointed out that of the factors enumerated, distance from the equator, distance from the sea, and altitude were, in short periods of history, constants, and that unless deforestation could be shown to have had an appreciable effect, we are thrown back to the assumption that climatic variations through comparatively short periods of history must result from changes in atmospheric circulation, which changes must be further investigated.

If to variation in the atmospheric circulation are due the pulsations in climate which we know have occurred down through the centuries and in our own time, how much more certain is it that the variations from year to year are attributable to a somewhat similar cause?

The question to be considered then is—apart from the constant factors which produce the distinctive characteristics of the climatic zones—what are the more direct varying conditions which lead to abnormalities and is it possible to account for these changing conditions?

The past two winters, that of 1918 and that of 1919, were in strong contrast; the former was phenomenally cold and the latter phenomenally mild. Why the difference?

It will be in order to describe what may perhaps be termed the normal distribution of atmospheric pressure, and then show in what respect the distribution of atmospheric pressure in these two years has differed from normal and led to unusual air movements.

Observations on the surface of the earth and of the atmospheric currents, as indicated by clouds and the ballon-sonde, indicate a primary distribution of atmospheric pressure and a general air circulation about as follows:

A belt of low pressure around the globe in the equatorial regions; both northward and southward the pressure increases towards a belt of high pressure between 25° and 30° north and south latitude and the outcome of this distribution is the northeast and southeast trade winds of the Tropics. As the latitude increases beyond the high pressure belts, the pressure gradually diminishes and the barometric gradient of the middle and higher latitudes produces the prevalent westerly winds. If the globe were all land or all water this distribution of atmospheric pressure, and hence the winds, would probably be almost constant and simply fluctuate somewhat in latitude with the annual change in the sun's declination.

But the earth is part land and part water and the very different absorptive and radiating properties of land and water lead to a secondary atmospheric distribution which changes with the seasons and is impressed on the primary system. In the colder seasons over the continents, the high pressure of the primary belts becomes higher and in both the Eastern Hemisphere and the Western Hemisphere overspreads towards higher latitudes, while in the warmer seasons the high pressure either diminishes or disappears and low pressure takes its place.

As far as is known the great cold waves which form over the northern parts of the continents in winter are the outcome of the radiation of heat from the land, and lead to anticyclonic conditions. In normal seasons the anticyclones and cold waves thus formed in the north, move southeastward to lower latitudes, alternating with but outbalancing the low areas which move eastward, carried with the general drift of the primary system of circulation.

The mean barometric charts show how the resultant of atmospheric changes and movements is high pressure over the continents in winter while in the North Pacific and North Atlantic the barometer is low. These low centers have been termed *centers of action*.

But a study of monthly charts of single winters shows a marked variation in the contrast between the continental high pressure and the ocean low. In some winters in Canada, it is high pressure in northern latitudes which dominates our weather, while in other winters the continental HIGH seems to be overpowered by the Pacific LOW which most persistently in the form of deep cyclonic areas prevents the formation of anticyclones over Yukon and the Mackenzie River Basin, and the result is the formation of barometric gradients which produce a general flow of air from south to north over Canada and hence higher temperature than the normal.

In the early part of the winter of 1917-18 the anticyclonic type was more pronounced than in any other winter on record, and with most persistent areas of high barometer coming in over Yukon, perhaps indeed offshoots from the great Siberian winter anticyclone, the North Pacific LOW pressure was situated much further south than usual and its offshoots, in the form of travelling low areas passed into Canada over southern British Columbia and thence kept away to the southward, and the result was a prevalence of northerly winds, not only in the western provinces but also in Eastern Canada.

During the winter just closed we find conditions in strong contrast to those of the previous year; the North Pacific LOW was extremely energetic and in a stream of offshoot cyclonic areas which impinged on the northern Alaskan coast, prevented the formation of anticyclonic conditions, and passing first southeastward, finally moved eastward as dispersing areas across the western provinces, there giving most persistent gradients for southerly and southwesterly winds with unseasonably high temperature. I shall not go into details regarding the various months, contenting myself with this general outline.

The problem which has then first to be solved would appear to be that concerning the *centers of action* in the North Pacific and North Atlantic—why in some years so much more pronounced than in others?

An important point will be—what conditions appear most favorable for the development of LOW areas? In an address before the Royal Society of Canada in 1914 the writer said: "We do know, however, something of the conditions which are very obviously connected with the development of cyclones, perhaps, indeed we have more certain knowledge regarding this than of any other meteorological activity, *e. g.*, in the colder seasons when cold continental winds in the rear of a shallow trough of low pressure reach the coast line of the Gulf of Mexico or the middle Atlantic, there is almost certain to be a marked storm development, with heavy precipitation. Moist warm air of the Gulf Stream on the one side and cold continental air on the other, lead to a rapid cyclonic development and the greater the contrast in temperature, the more pronounced will be the storm." It is clear that warm moist air is a most important factor, and the warmer and moister it is, the better are the conditions for cyclonic development.

The writer believes that the time now is when increased investigation should be carried on regarding the changes, both in the position and temperatures of the great ocean currents. If it can be shown that the great Japan Current in some years carries its warm waters further north than in other years, it may not improbably be subsequently shown that in such years cyclonic conditions are more intense near the Alaskan coast, and we shall at once have valuable information regarding the probable distribution of barometric pressure in Northwestern America, and this appears to be a dominating factor in the character of our winter seasons.

In the bulletin of the Scripps Institution for Biological Research, November 8, 1918, Mr. George F. McEwen reviews the various theories of the cause of oceanic circulation from ancient times to the present, and urges concerted action by the governments in a survey of the ocean currents and their variation in position in different years.

While it would appear probable that conditions that would increase the temperature and the flow of ocean currents would act simultaneously in both hemispheres, it does not necessarily follow that the effect on the northern coast of Europe would occur simultaneously with the effect on the northwest coast of America. One would surmise that as the source of the Gulf Stream is nearer the British Isles than is the source of the Japan Current to Alaska, therefore Europe would be affected before America and quite possibly this is the case. The whole question is complex but well worthy of study.

*From *Jour., Roy. Astron. Soc.*, Canada (Toronto).

[1] *Jour., Roy. Astron. Soc.*, Canada, 1917, v. *11*, p. 197.

Microstructure of Iron in Electric Welds

LAST year Mr. S. W. Miller contributed a paper to the American Institute of Mining Engineers on "Structures in Steel Fusion Welds," during the discussion of which various conflicting opinions were expressed as to the nature of the small needle crystals observed in oxy-acetylene and electric welds. The discussion induced Mr. F. G. Comstock of Niagara Falls, further to examine a weld made on a piece of steel plate, ⅜ in. thick, on which iron had been deposited to a depth of 3/16 in. by arc welding; the weld appeared very good, and did not show any boundary between the plate and the iron. Sections were cut in three planes at right angles to one another through the deposited metal and the steel plate underneath. The polished sections showed round gray oxide spots and after etching with nitric acid also the pale needle crystals of what Miller regarded as cementite, Jeffries as martensite, and Ruder and Boylston as iron nitride. Under the microscope the boundary between the steel and iron became sharp; the steel immediately underneath the weld appeared coarse-grained, lower down it was finer. Small sections were then cut; the one was annealed at 500° C. (*i. e.*, below the critical temperature of the steel), and the other at 900° (above that point); the former was cooled in lime, the latter slowly cooled in the furnace. The fine micrographs of the sections obtained are reproduced in the January, 1919, Bulletin of the Institute. Analyses of filings were also made, and as only 0.04 per cent. of carbon was found, Comstock concludes that the pale crystals cannot be cementite or martensite, but are probably iron nitride. This conclusion is supported by etching tests made with sodium picrate and by the detailed study of the micrographs which indicated that the needles when slowly cooled after annealing diffused into the steel but did not merge into the pearlite of the steel. Direct evidence in favor of the nitride formation is however, not given.—*Engineering* (London).

Ageing of Mercury Vapor Lamps

W. COBLENTZ, B. Long, and H. Kahler have determined the decrease through age of the ultra-violet radiation of quartz mercury vapor lamps. The intensities have been measured by means of a bismuth-silver thermo-electric couple and a galvanometer. A water vat, 1 cm. thick, with a quartz window in front of the thermo-electric couple absorbed the infra-red rays of great wave-length ($\lambda > 1.4\mu$) emitted by the electrodes and the envelope. The complex pencil of rays may be considered as emitted by the mercury vapor; its spectrum consists of intense lines in the ultra-violet region in the visible part and in the infra-red up to towards 1.4 μ. The ageing of the lamps is due to the blackening of the quartz or to a kind of crystallisation, which renders it less transparent to ultra-violet rays.

The simplest method of studying the ageing of the lamp would consist in using a screen transmitting all the U.V. rays and absorbing the visible or infra-red rays, or *vice versa*, but no such ideal screen exists. The authors have, however, used a dark yellow glass (Corning Noviol, shade B) which absorbs all the U.V. rays having a wave-length less than 0.4 μ and whose transmission does not depend upon the power absorbed by the lamp (between 100 and 200 W.). The deviations of the galvanometer caused by the thermo-couple were measured (1) directly after the passage through the water bath, which stops the radiations of great wave-length emitted by the tube walls; (2) after interposition of the yellow glass. The rates of these deviations or transmission coefficient increases as the proportion of U.V. rays decreases, that is, as the tube gets older. The trials were carried out with lamps made by the Cooper-Hewitt Co. and the R.U.V. Co. The following results were obtained: (1) the proportion of radiated U.V. rays with a wave-length of 1.4 μ (upper limit), which is 70 per cent. in a new lamp, becoming 50 per cent. after 1,000 to 1,500 hours' working; (2) during the first 500 hours there is no perceptible difference between the percentages of U.V. rays emitted by both types of lamps; (3) the total radiation of the lamps decreases by one-half or one-third of its initial value after 1,000 or 1,200 hours of working.—*Revue générale de l'Electricité.*

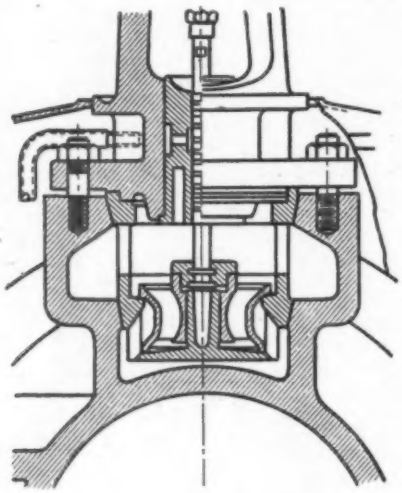
Notes on Drop Valves for Steam Engines*

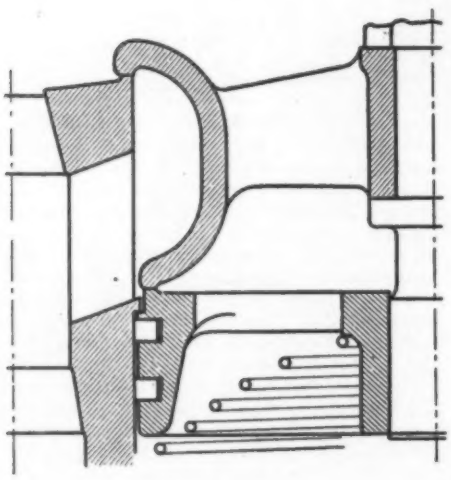
Results of Experience With Slow-Speed Land Engines, Perhaps Useful Also in Designing Other Types

By H. W. Morley

THE following notes are obtained from experience gained mainly in the construction of slow-speed engines for land service. While the information given will perhaps be useful to students of that type of engine particularly, it may also be of help to those who have the design of other types of engines under their care.

Superheated or dried steam is now in general use for land engines, it having been proved that economy is obtained by its use. Where cylinder clearance areas and volumes are the greatest, there, also, is the greatest economy obtained by superheating. But there are other practical advantages in the use of superheated steam; hence its general use, even when the engine is of the best design. Consequently, the valves must be suitable for use with superheated steam.





Figs. 1 and 2.

The Cornish double-beat valve is perhaps the oldest type of valve used in steam engine practice. It is generally constructed as shown in Fig. 1, with an independent seat let into the cylinder and made a ground fit. This type of valve is usually opened by a detent or trip gear on the steam inlet and by cam gear on the exhaust, and in both cases closed by springs. Now, when in work, the inlet valves are subject to more or less hammer action on the seats. While this hammer action is not found materially deleterious when the engine is working under fairly constant loads, it was discovered soon after its introduction that it was a serious disadvantage when used with variable loads, such as those experienced in the early days of electrical generation. Many forms of dashpots and complicated forms of valve mechanism were tried in the endeavor to overcome the difficulty, but none were really satisfactory. The valves could not be maintained reasonably steam-tight, even at very low speeds. Later, a cam form of mechanism was developed for the steam valves, of which the Lentz gear—illustrated in Fig. 3—is a good example. In this form of gear the valve is kept closed by a spring and opened by a cam. In closing the spring keeps the roller in contact with the cam, thus avoiding serious hammer action. The result of this improvement is that the valves can be kept reasonably steam-tight with saturated steam, and can be allowed to seat themselves on the cylinder casting, thus reducing the cylinder clearance volumes and areas.

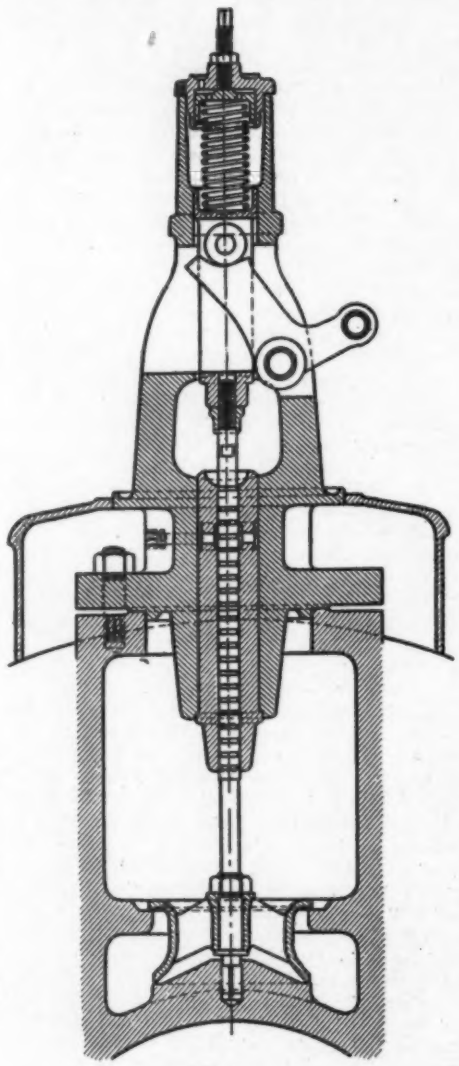


Fig. 3.

Now, all steam cylinders become distorted with heat, and while this distortion was small and could be adjusted or allowed for with saturated steam, it is found that with superheated steam the changes of form are greater and cannot be satisfactorily allowed for. This disadvantage is increased in work by the practical impossibility of keeping the superheat temperature nearly constant, especially in factory work, where it is usual to shut down three times per day. Furthermore, the valve being at a temperature closely corresponding to the temperature of the steam, while the seat temperature is more nearly that of the cylinder, it is practically impossible to keep poppet valves reasonably steam-tight, no matter what shape the seats may be. To overcome this difficulty, various devices have been tried, more or less successful in work, although expensive to manufacture. One method is to make one face of the valve or seat flexible. This method demands a wrought steel construction, and is consequently expensive. Moreover, in nearly all installations foreign matter in the shape of boiler scale from priming, from pipes, and—not by any means rare—stray pieces of jointing material, finds its way into the cylinders, with disastrous results to the flexible part.

It must not be overlooked that one-thousandth of an inch is large when considering valve leakages, and that consequently distortions of this small dimension are important.

Another method is to make the bottom face of the valve seat on a piston—as illustrated in Fig. 2. With this design most of the difficulties have been overcome, and for temperatures up to 600 deg. Fah. valves can be maintained reasonably steam-tight. But it will be obvious that the rings of the seating piston, as well as the valve seatings, must be a ground fit. I have found that flat faces to the valves 1/16 in. to 1/8 in. wide, according to the diameter of the valve, give the best result, and with good close-grained cast iron it is seldom necessary to exceed 5/16 in. thickness of metal in the valve.

In my opinion, no form of main working engine valve can be maintained absolutely steam-tight in work. Most kinds can be made steam-tight for testing in a stationary condition. The Cornish double-bent valve operated positively by cam gear, as explained, is one of the best. It can be worked without lubrication, except in so far as it is necessary in order to avoid the bad effects of rust. The power to work them is low, being balanced and light, their speed of operation is only limited by the speed at which a cam gear can be satisfactorily worked. Springs are, however, always necessary.

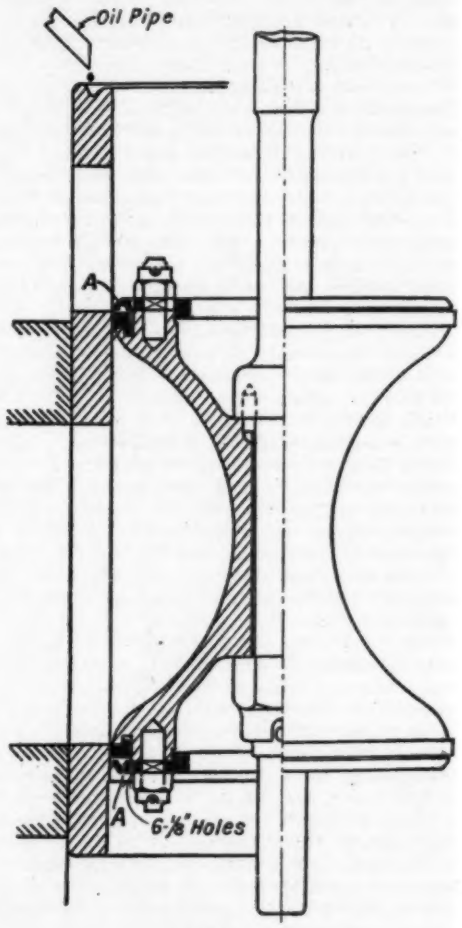


Fig. 4.

The piston valve used as a drop valve is a comparatively modern development. In its older form, where one valve fulfilled the duty of admitting and exhausting the steam, it has a bad character for steam leakage, but when used so that its only function is to admit or exhaust the steam, it is much easier to overcome its inherent defects. Fig. 4 illustrates a steam admission valve, the constructional and manufacturing points of which may not be at once obvious. The valve works in a separate liner forced into the cylinder, the seatings being machined and, if necessary, scraped, so as to be circular when cold. The result of pressing the liner in is that where it touches the cylinder it is contracted. Hence, where the rings seat the bore of the liner becomes less than on either side of that seating. If the ports be cast in, the liner has a tendency to crack, and they are therefore cut from the solid. Now, the rings are restrained by a return flange on the faces. In the steam valve shown they are on the inner faces, but in

*From *The Engineer* (London).

the exhaust valves they are on the opposite faces. On those faces between the restraining flange and the liner, the rings are a ground fit to the valve, hence steam-tight. The ring is not a tight fit in the groove, but is kept up to its face by a wave spring in the recess A, shown. Further, the rings are steam packed, in the case of the inlet valve, by the incoming steam, and of the exhaust valve by the cylinder steam, or from the side on which there is the greatest pressure. The joints in the rings are not lapped, but usually just radial, and the joint is pegged opposite one of the grids in the liner. The valve body is clear of the liner, and does not touch in work. It is pegged, so that it cannot turn on the spindle, and all is so arranged that once set the valve commences and ends its life without circular movement. But it is necessary that the gland should not prevent the spindle from making slight movements at right angles to the axis of the liner. In work, then, the cylinder will distort the valve liner more in some design of cylinder than others, but the rings being flexible to the necessary slight amount, follow at first the irregularities and later wear to them. At first sight the restraining flange may appear to prevent this automatic adjustment, and it was at first only used to prevent parts of the rings getting into the ports in case of breakage, but piston rings in work, whether in the piston or valve, expand more than the cylinder or liner—at least, all the writer's experiments have proved this—and, again, the rings are made a fit to the liner before it is forced in. Hence, when the valve is on the seating part of the liner, the rings are off their restraint. With care, then, these valves can be maintained reasonably steam-tight. The wear is very small. Seven years' wear on night and day running, or about 300 million revolutions of the engine, showed that the joints of the rings were 34/1000 wider apart than when they left the shops, or a diametrical wear of rings and liner of about 1/100 in., and this with 160 lb. boiler pressure and temperatures up to 630 deg. Fah.

The piston valve has lap, hence can be worked by positive gear without springs, and it is suitable for variable load when operated with the simplest of detent gear and lightest of dash-pot springs.

The cost of engines fitted with either of the above forms of valves has not been found greater than with Corliss gear. If they be carefully examined and the whole design of engine adapted thereto, it will be discovered that all the operating gear parts lend themselves to easy standardization, and that even in the pattern-shop and foundry the elasticity of the valve casing patterns helps. The power required to operate these two types of valves is less than for many others, as being balanced and light the mechanical efficiency is higher; the wear and tear is also less. Perhaps the most important, from a salesman point of view, is that the gear can easily be designed, even if trip or detent gear, to work almost noiselessly.

When these valves are placed in the cylinder bodies, the clearance volume is perhaps greater than with the Corliss valve, but when in the cylinder heads there is no practical difference. The lowest steam consumptions and the highest steam efficiencies have been obtained on engines fitted with these forms of valves, and it seems as though those results would be maintained better with them than with any other form.

The Use of Pulverized Coal—II*

We continue below our review of the report on the use of Pulverized Coal, made by Mr. Leonard E. Harvey to the Fuel Research Board of the Department of Scientific and Industrial Research.

On the question of spontaneous combustion Mr. Harvey observes that it is sound practice not to store more than forty-eight hours' supply of dried coal. Spontaneous combustion is not likely to occur in that time providing that the coal as delivered from the drier is not overheated. The temperature at which it leaves that apparatus should ordinarily not exceed 200 deg. Fah., but the permissible temperature depends upon the nature of the coal and its ash. Not more than a twenty-four hours' supply of pulverized coal should be stored on the mill-house, and it is considered advisable to store only sufficient coal in the furnace bin to last for one shift—eight hours or so. It would not appear, however, that much difficulty has been experienced in America from spontaneous combustion in the mill-house. Mr. Harvey mentions cases in which as large a bulk as from 30 to 40 tons of pulverized coal had been stored for three or four weeks without any sign of spontaneous combustion. In the neighborhood of the furnace, too, bins holding 10 to 15 tons of pulverized coal have been known to remain charged for three or four weeks without ignition. On the other hand, fires have occasionally occurred overnight. The only effect of spontaneous combustion is, apparently, to produce a slight caking in the center of the bulk. The actual fire is ultimatley self-extinguished in the absence of sufficient oxygen to support combustion and by the generation of carbon dioxide gas.

As regards explosions, Mr. Harvey states that at none of the works that he visited was it found that any special precautions had been taken against explosion of the coal dust other than those dictated by common sense. "Installations," he remarks, "had been in use without any explosion having taken place for so many years that the danger of explosion had almost been forgotten." In some of the older plants, mills, bins, girders, stairs, elevators, &c., were thickly coated with coal dust, and, remarks Mr. Harvey, "an unnecessary risk of fire, if not of actual explosion, is being courted in several plants." However, he continues, "The existence of such conditions in the mill-house for years without mishap should reassure those who are excessively fearful of coal-dust explosions." At new plants apparently greater attention is being given to keeping the mills and mill-house clean, and Mr. Harvey adds, "In fact, the new types of mills and the care now given to design of plant makes for a dust-tight equipment." In storing powdered coal the following precautions are recommended: (1) Limit the height of the coal pile to 10 ft. or 12 ft.; and (2) isolate the coal from all sources of heat such as steam pipes, flues, reflecting surfaces, and direct sunlight.

In Chapter V. illustrations—which we do not reproduce—are given of the Quigley, Lopulco, Bergman, and Fuller and Pruden burners. It is explained that the present tendency is to use low-pressure air supply for mixing with and introducing the coal dust into the combustion chamber or furnace, thus allowing the particles of ash to settle out before reaching the work to be heated or the boiler tubes and surfaces. Burners are therefore, says Mr. Harvey, not as a rule of a complicated nature, and more often than not the coal dust is simply allowed to fall by gravity from the feed screw into a single pipe, which carries the air for the combustion of the fuel. The pressures used vary from 2 oz. up to 6 oz. per square inch, but the lower the pressure the better. One form of Quigley burner has a double air supply, provided from one source. The primary air has an ejector action upon the supply of powdered coal. The initial mixture of coal dust and air is then introduced into the main air supply just prior to its entry into the furnace. The pressure of the air supply at the point of entry of the fuel is about 2 oz. to 3 oz.

The Fuller burner usually consists of a single air pipe or burner tube into which the coal dust falls by gravity from the screw feeder. The pressure of the air supply is generally 2 oz. per square inch.

The Bergman burner is fitted with an internal cone arranged concentrically within the air supply pipe, and the coal dust is fed in by gravity in such a manner that it forms a complete film or coating to the air jet, the purpose being to introduce the air into the furnace in the center of a covering of fuel. It is contended, says Mr. Harvey, that when coal dust is fed into the center of the air jet the latter expands away from the pulverized fuel and an imperfect mixing of the air and fuel in the furnace results.

The "Lopulco" mixer is combined with the screw feeder. The burner consists only of the pipe through which the mixed coal and air is conducted to the furnace. In practice, air is supplied at 6 oz. to 8 oz. pressure and enters the jacket surrounding the delivery end of the screw feed. At that point the mixed coal and air is given a whirling motion by means of the paddle blades, which assists the intimate mixing of the fuel and air for combustion. From the combination feeder-mixer a number of burner tubes can be supplied.

With regard to other burners, Mr. Harvey states that the Heyl and Patterson Company, of Pittsburg, which controls the "Covert" system, has several types of burners or mixers, one of them being of special interest. Into it the coal dust falls in the usual manner by gravity and descends on to diaphragm shelves projecting one below the other and fitted horizontally across the air inlet pipe or burner tube. Air is supplied at 2 oz. or 3 oz. pressure and picks up the coal dust on passing between the shelves. All the feeders hitherto referred to, with the exception of those of the Quigley type, operate with variable-speed motors for the control of the supply of coal dust to the burners. The Quigley feeder is fitted with adjustable jaws, through which the coal dust is passed to the burner. The feed screw can therefore rotate at a constant speed.

Finally, reference is made to the "Pruden" carburiser or mixer of Chicago. The apparatus effects, according to Mr. Harvey, perhaps the most perfect mixture of coal dust with air. The powdered coal, as it is withdrawn by a screw feeder from the bunker, is mixed with a primary supply of air and the mixture is then conveyed to a second chamber, in which the balance of air required for combustion is introduced into the primary mixture.

Chapter VI., which contains the opinions of numerous users of powdered coal fuel, applications of the system, working results, &c., is already in so condensed a form that it is practically impossible to compress it further. It is full of valuable and instructive matter, however, and those interested in the question of powdered coal fuel will be well repaid by obtaining a copy of the report and reading it *in extenso*.

Chapter VII., which deals with Mr. Harvey's conclusions we reproduce in its entirety as follows:

(1) The advantages of burning coal in pulverized form have been definitely proved in actual practice.

(2) The heat values of coals can be utilized to a far higher degree by this means of firing than by any other process.

(3) In certain circumstances initial costs for pulverized coal plants are considerably less than the costs for installing producer gas plants.

(4) Economy in fuel consumption of from 20 per cent to 50 per cent can in many cases be effected by the use of coal in pulverized form.

Of the 513,500,000 tons of coal used in America in 1914 for all purposes, of which, say, 205,400,000 tons were used in the metallurgical and steel industries and for railway locomotives, some 41 million tons would have been saved if pulverized coal had been used exclusively for these purposes.

(5) There is little or no economy to be effected by the introduction of pulverized coal burning apparatus in substitution for existing efficient mechanical stoker installations, but for initial installations the latter plant can be installed at a lower cost and will show increased overall economies over mechanical stokers.

(6) Almost any grade or quality of fuel—anthracite, bituminous, lignite, or peat—can be used efficiently in certain circumstances in pulverized form.

(7) High ash fuels, containing 30 per cent or 40 per cent ash, can in some cases be used.

(8) Large quantities of what is considered waste coal can be used to good purpose, and culm and slack heaps at mines can be at once turned to profitable account.

(9) In suitably designed plants there is practically no danger whatever of the possible explosion of coal dust.

(10) With the precautions as to limited storage recommended, spontaneous combustion introduces no apparent difficulties.

(11) That the slag or dust resulting from the ash in coals can be conveniently and effectively handled and removed from all classes of melting and heat treatment furnaces, stationary boilers and locomotives, small furnaces such as rivet-heating furnaces being an exception.

(12) A very important start has been made in connection with the firing of large power-house boiler plants by this means, and its extension in this direction is likely to develop rapidly.

(13) In view of the attention now being given to marine boiler firing by this means, useful and important results are to be expected.

(14) Owing to the very considerably reduced amount of labor incidental to a pulverized coal plant as compared with hand firing and, in certain cases, stoker firing, the labor saving is a most important feature introduced by this system of burning coal.

Saving in labor is particularly marked in connection with the firing of railway locomotives by this means.

(15) In view of the smokeless combustion of pulverized coal in metallurgical furnaces, and especially in the steel industries, for boiler firing and for locomotives, the abatement of smoke nuisances in large cities by this means can be accomplished to an appreciable extent.

Appendix I. gives a list of the systems investigated in the United States by Mr. Harvey, with the addresses of their proprietors. Appendix II. is devoted to a list of installations visited, with brief details in each case of the particular direction in which the powdered fuel is applied. Appendix III. contains a fairly extensive list of powdered fuel users, while Appendix IV. embodies the Bibliography.

*From *The Engineer* (London). No. I appeared in Sci. Amer. Suppl. No. 2276, p. 110.

Ants of High and of Low Ability*

A Study in the Psycho-biology of Various Ants

By Robert Stumper, Luxemburg

[Editorial Note.—The present article in a German scientific journal which is once more being received in this country, after the interregnum due to the war, is gracefully and gratefully dedicated to the famous Swiss scientist, Dr. Auguste Forel, one of the world's greatest authorities upon the psychology not only of ants but of the human brain, upon the occasion of the celebration of his seventieth birthday on September 1, 1918.]

THE species *Leptothorax* belongs, together with the pale-arctic genera *Formicoxenus, Stenamma, Harpagoxenus, Anergates*, etc. to the *genus* of the *Leptothoracini*.[1] The characteristics of this species consist, in the first place, of a striking tendency to the formation of races and varieties; and secondly, in the biological characteristic that the different kinds constantly build their nests in the same specific manner, namely, under foliage in hollow twigs, etc. The *Leptothorax* are without exception phlegmatic and peaceable little creatures. This psychological characteristic connected with the above mentioned ones stamps them as belonging to the so-called "lower" ants. The study of the less highly specialized and psychologically less gifted ants is peculiarly interesting and important, for it is among these that we learn to understand the actual behavior of the Formicides and we are thus in a position to explain the evolution of races among ants by means of comparative psychological data. Thus we learn also how to trace the higher psychology of the "upper" ants back to the "lower" forms, which will certainly prove to be of use in the comparative psychology of ants. There is little to be found in the literature of ants concerning these lower forms, unfortunately, so that much research remains to be made along this line. Let me call attention, for example, to the methods[2] in use in the new animal psychology: Labyrinth, Choice method, etc.

The chief characteristic of the various kinds of *Leptothorax* is as we have said, a phlegmatic peaceableness. This quality is the natural basis of the frequent cases in which we find the *Leptothorax* sharing a double nest with other kinds of ants. Such instances are frequently mentioned in the literature of ants, e. g. Wasmann No. 177; *Leptothorax* (*Mychothorax*) *acervorum F.* with *Formica trunciola, F. rufa, F. sanguinea, F. fusca, Myrmyca*, etc. We can readily understand also from this circumstance why many investigators trace back the guest ants (*Formicoxenus Nitid ulus Nyl.*) to such double nests.[3]

Certain varieties of the *Leptothorax* and among these particularly L. *tuberum F. r. affinis Mayr*, live lawabidingly in hollow twigs of the nut trees and blackberry bushes. At Neuenstadt on the Bieler Lake I had a favorable opportunity for making a close study of the ant fauna of the nut trees and I purpose to set down here the results of my observations and experiments, in so far as they seem of interest, and to make a critical analysis of them.

THE ANT FAUNA OF THE NUT TREES.

In 1874 Professor A. Forel[4] called attention to the fact of the regular presence of the *Leptothorax tuberum n. affinis M., the Dolichoderus quadripunctatus L.* and *Camponotus* (*Colobopsis*) *truncatus St.* upon nut trees and oaks. Thi slaw-abiding life together first became clear to him after the discovery of the stem dwelling ants of the Colombian savannahs.[5] He found, namely, that the three kinds of ants mentioned above have their nests in the hollow pith tubes of dry nut tree twigs and *Colobopsis* and *Dolichoderus* even build polydome colonies while *Leptothorax affinis* lives in small independent colonies. R. Staeger[6] repeated Forel's researches and discovered the same state of affairs in dry blackberry twigs.

At Bieler Lake on the southeastern slope of the Jura I found altogether the following ants upon the *Juglans regia*:

(1) *Leptothorax Nylanderi Forst.* (one colony).

(2) *Ibid Tuberum F. r. affinis Nayr.* (a very large number of colonies.

(3) *Ibid Tuberum F. r. affinis Nayr.* of *tuberoaffinis For.* (from six to eight colonies).

(4) *Ibid Tuberum F. r. unifasciatus* of *unifasciatointerruptus For.* (one colony).

(5) *Dolichoderus quadripunctatus L.* (very abundant).

(6) *Camponotus* (*Colobopsis*) *truncatus Sp.* (one colony).

These ants . . . inhabit the dry twigs which frost or some other injury has caused to die. The ants find it an easy matter to remove the flakes of pith and thus find themselves in possession of a comfortable location for their nests until some mischance, such as a high wind or the poles of a nutting party break off the twig with its inmates. By reason of such accidents a rich booty of ant nests is to be found in the twigs lying around such trees.

But the stem dwelling ants also bore side passages; moreover they probably use the borings left by the *Capronidæ* or Capricorn beetle *larvæ*. I found colonies of the *Leptothorax affinis* in all stages: solitary queens with and without a brood as well as young, half grown and adult colonies. The latter contained from thirty to fifty ☿☿ and one to three females. I found Forel's observations with respect to the polydome colonies of the *Dolichoderus* confirmed in the Neuenstadt material; on the one hand I found the more frequent lack of the female in colonies and on the other hand I was able to prove the connection between the separate colonies experimentally. *Without exception the inmates of various twig nests united to form a single colony in an artificial nest.*

How shall we explain the singular "*Hemi-symbiosis*" of these three kinds of ants which belong, furthermore to three different sub-families?

There is nothing surprising in the fact that three different kinds of ants have the same habits of life. We are familiar, indeed, with countless convergent phenomena in the various species of ants (e. g. colony foundations, etc.). Far more remarkable is the peaceful community life upon the same substratum of these little creatures. Thus Forel found upon a nut tree nine nests of the *Dolichoderus quadrip.*, seven nests of the *Leptothorax affinis* and two of the *Colopopsis truncata.*

I, myself, found upon a single tree, in those dry twigs within my reach, three nests of the *Dolychoderus* and ten of the *Leptothorax*, while in the dry twigs strewed on the ground under the tree were three of the latter and one of the former. Another tree yielded three kinds of ants, the numbers being one, two and seven colonies, respectively. . . .

In order to investigate the peaceful neighborliness of these ants experimentally I made a series of tests, as follows:

Experimental Mixing I.—On July 23, 1917, I placed a small colony of the *Leptothorax Nyl.* in a glass tube. After they had settled down in their new quarters I added a colony of the *L. tuberum r. affinis.* Both these colonies had broods. After the first confusion during which both kinds of ants ran wildly about among each other, there ensued a period of quiet. During this time the ants felt of each other mutually and thereupon concluded peace without any show of hostility. They carried the broods together and made a thorough inspection of the new dwelling place. They maintained this harmonious relation until the middle of August when I emptied the tube.

Experimental Mixing II.—On July 28 of the same year I placed a colony of *Dolichoderus quadrip.* and one of *Leptothorax tub. r. aff.* in a beaker glass. These two colonies came from different trees. After the first disturbance occasioned by putting them together had quieted down the two varieties carried their broods into a hollow twig with which I had provided them. A day later, however, a separation occurred, the *Leptothorax* moving out with bag and baggage from within the twig and settling down outside. Thereupon single combats began to take place in which the stronger *Dolichoderus* obtained the upper hand. The result of this experiment was contrary to that made by Forel with the (*Colobopsis*) *truncatus* and *Dolichoderus quadrip.* which settled down and lived in peace together. Forel rightly regards this as exhibiting a tendency towards Para-biosis.

Adoption Experiment III.—I presented a *Leptothorax tub.* of *aff.* colony (with ☿ with a female of the *Leptothorax Nyl.* The result was negative for the strange female was badly mauled by the *affinis* female workers, and in consequence died a few hours later.

A Find of a Natural Case of Incomplete Para-biosis IV.—On August 27 I broke off the stump of a small twig from a nut truee. Upon splitting it I made the surprising discovery that it was occupied by two kinds of ants. Fig. 2 shows the arrangement. In the main channel *a* I found a small Colobopsis colony containing one ☿, one soldier and twelve ☿☿. In the side channel *b*-resided a tolerably large colony of *Lept. aff.* (1☿ and 25 ☿☿ with brood), obviously, therefore, both kinds of ants were living as immediate neighbors.

Let us now endeavor to interpret the observations described and the results of the experiments mentioned above. The cases of mixing and of alliance are closely dependent upon the problem of mutual recognition and we must take this as th estarting point for our analysis of the data at hand. For this purpose let me state briefly the outlines of the information we possess concerning natural and artificial alliances:

Ants of the same colony recognize each other by the smell of the nest and distinguish strange ants by the same means, whether the latter are of their own kind or of another race. The action corresponds therefore, to the external stimulus of smell (1) a friendly one when the smell corresponds to that of a familiar home nest (experience association); (2) a hostile one, when the smell is unknown. According to the admirable experiments made by Brun,[7] this scent of the nest consists of two components, a specific general smell (Globalgeruch) which is exhaled by the queen—the true colony smell; and second, an individual scent which appears to be mingled with the first and to proceed from the odor peculiar to the locality of the nest. The latter may itself be divided into two components, and as a matter of fact, in my opinion, the individual smell does not arise simply and solely from the chemical composition of the nest, but from the countless glandular excretions of ants which may vary in individual ants.

This colony smell of the ants has, indeed, its human analogues, just as cattle breeding, mushroom raising, and weaving are practiced, both by human and by "ant" operators. It is a familiar fact that the odor of the dwelling varies in different human families and it is hard to find two houses which have the same odor when they have long been occupied.

The mixed colonies and especially the artificial mixtures obtained by shaking together two colonies within a container might possibly, therefore, be interpreted by saying that a uniform neutral colony odor is created to which the ants thereafter react in a friendly manner. This explanation is erroneous, however, for the following reasons: In the first place the reaction to the aforesaid new and uniform nest odor would necessarily be a hostile one on the part of both tribes, and secondly, it has been demonstrated by Brun that the mingled odor does not make its appearance until some little time after the mixing of the tribes has taken place. These two reasons are entirely sufficient to discredit the chemo-reflectory explanation suggested by Bethe and they oblige us correspondingly to attempt a closer analysis of the psychological factors which here come into play. The first factor operative is the compulsory situation. The ants have been violently torn away from their natural environment and conditions, and the *new* and *powerful stimuli to which they are subjected inhibit the mechanism of the normal instincts and thus further the peaceful union of the kinds of ants.* Secondary factors also come into play to further the formation of the friendly alliance, such as the number of ants involved and the presence of the brood and the queen. Furthermore, the important factor of time is involved in the mutual accommodation of the insects and the gradual formation of a mingled odor.

Hence we must regard the mixed colony, not as the

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*Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from the *Biologisches Zentralblatt* (Leipzig).

[1] A. Forel. A brief Synopsis of the present state of the Universal Fauna of the Ants. *Bull. de la Soc. Vaud. des Sciences Nat.*, 1917, *51*, p. 244.

[2] Skeat. "Animal Psychology," in Claparède Handwoerterbuch f. Naturwis., 1913.

[3] R. Stumper. *Formicoxenus nitidulus Nyl.* I. Btrg. Biol. Zentralblatt, 1918.

[4] Forel. The Ants of Switzerland, 1874, p. 227.

[5] Forel. Myrmicological fauna of nut trees. *Bull. de la Soc. Vaud. des Sciences Nat.*, 1903.

[6] R. Stäger. A Study of the Stem Dwelling Ants in Switzerland. *Revue Suisse de Zoologie*, 1917.

[7] R. Brun. Concerning the Biology and Psychology of the *Formica rufa* and other ants. *Biol. Zentralbl.*, 1910, No. 15. ——The Psychology of the Artificial Alliance Colonies among Ants Journal Psychology and Neurology (in German), 1913.—*Ibid* and E. Brun. Observations in the Kempthal Ant Territory. Biol. Zentralbl., 1913.—*Ibid* in K. Escherich's "The Ants," second edition, chapter X.

result of a simple olfactory-physiologic stimulus, but rather as that of regulative psychological activities whose principal elements consist in the new stimulus complex and mutual accommodation, i. e. an association of the social instincts with the newly operative elements. Thus regarded the analysis of the artificial experimental mixture furnishes a clear and generally valid point of departure from which there branch off in one direction the problem of artificial alliances, and in the other, that of natural alliances. This holds good exceptionally for all higher ants, e. g. *Formica*, *Lasius* and *Camponotus*.

In the case of the lower ants another field of experiment is opened which I have been fortunate enough to penetrate by means of the experiments described above.[1] A priori we must not forget in the interpretation of these experiments to take into consideration the biological and psychological peculiarities involved, making these the basis of further investigations. As I have said, in the case of the *Leptothorax* these consist in peaceableness and a phlegmatic nature. For this reason the reaction of the various kinds of *Leptothorax* in the mixing experiments are milder in character than among some other ants. It follows from this that among these ants the intensity of the hostile reaction to a new odor is weaker than in the higher ants. In the *Leptothorax*, however, the secondary stimulus of the presence of queen and brood comes into play in the mutual accommodation.

Thus we see that in experiments I and II the alliance was made without hostility. Matters were different in the adoption test III. In this case the *Nylanderi* queen was attacked and that proves what was said above, that secondary factors come into play. However, the question of the adoption of a female among ants involves another aspect of their psychological expression. During the last decade a strong light has been thrown upon the biological phenomena of adoption and our knowledge along this line has been greatly extended. And certain biological evolution-series are of special importance in this respect, since the attempt has been made to explain in this manner the facts of slavery and social parasitism.[2] The psychological side of these interesting observations and experiments still needs considerable light thrown upon it. Without attempting in this place to go very deeply into this problem, which must be solved by special and adequately extended series of experiments, I will undertake to offer certain suggestions.

It is a well-known fact that many ant-females after the wedding flight are taken in by other kinds of ants where they complete the work of procreation, allowing their brood to be reared by the strange female workers. Normally, the ant female digs a burrow and feeds and cares for the brood herself, *remaining active in this manner* until the first workers have been reared. The queen, thereupon, immediately sinks to the position of a mere egg-laying machine and no longer troubles herself about the brood, leaving such cares to the workers. Thus we see the psychological behavior suddenly transformed with the development of the first set of workers. This is a mere consequence of the inherited social instincts, a result of the division of labor. The females of those kinds of ants which have a dependent colony foundation have the psychological property of seeking out other kinds of ants; we shall not now concern ourselves with the origin and development of this instinct but examine the nature of the psychological factors concerned in the adoption itself.

The acceptance of the strange queen is naturally connected with a similar outward form and we, therefore, find adopted females only in closely related ants, or in those whose structure is pretty much the same. A too heterogeneous form would occasion a hostile reaction when the ants felt of each other. This, however, is of merely secondary significance. In the matter of adoption the effect called forth by the odor is of the chief importance. The intensive colony odor clinging to the female is lessened during the marriage flight and still more so after the subsequent wanderings of the female; and the original hostility-rousing odor is partially cloaked by accidental odors of the ground, etc. Thus the female seeking to be taken in passes through a useful quarantine.

But she is not yet adopted. It is quite certain that large ant colonies almost never take in strange females. On the other hand such a reception of an outsider is greatly facilitated by the lack of a queen belonging to the colony itself or by the circumstance of the colony being small in numbers. Here, too, we must take into consideration powerful "plastic" activities which are based without exception upon individually acquired associations. *The taking of strange females into ant colonies is, therefore, conditions by special phychoplastic dispositions of the workers.* I, therefore, regard adoption as belonging to the instinct-regulations whose basis consists in individually acquired associations. The life of ants is crowded with such social-phychological corrections which regulate the mechanism of instinct by individual "plasticisms," conduct it into useful paths, and thus bring about an adaptation to external advantages and disadvantages. As to the latter factor, *Accommodation*, repeated experiments in the receiving of strange females have caused the adoption to improve progressively. In this case the association of the new stimuli has been completed by the inherited instincts and has become a secondary automatism.

All in all we are justified in regarding the adoption process of the ant-female by a strange colony as the mark of a high degree of psychological activities, like the circumstance of allied colonies; these activities belong to the category of instinct-regulations and their factors arranged in the order of time are as follows:

1. Diminished nest odors of the female to be adopted.
2. Psychological situation of the adopting colony, including
   (a) A small colony ("consciousness of weakness");
   (b) Lack of a queen ("consciousness of weakness");
   (c) Psychological accommodation or adjustment.

In the case cited (the adoption experiment) it is evident therefore that the stimulation-complex "*Nylanderi* ♀" occasioned a hostile reaction among the *affinis* ☿ ☿ for the two reasons of the *foreign odor and of the presence of a queen of their own with her brood.*

Let us now examine a very heterogeneous collection of ants upon the nut tree (vide 1).

Camponotus (*Colobopsis*) *truncatus* (*a* and *b*, Fig. 1).
Dolichoderus quadripuncatus (*c*).
Leptothorax tuberum of affinis (*d*)

All these live together with no signs of hostility showing that they have mutually adjusted themselves to each other.

How shall we explain the psychological phylogeny of this ant community? My own experiments as well as Froel's indicate that there is a peaceful comity among them. On the other hand all other ants are mutual enemies; hence we are justified in regarding the present phenomenon as the result of a psychological development. In my opinion the nature and the factors of this phyletic adjustment are as follows:

1. The original state of the nut-tree ants must have been that of hostile neighbors.

2. In the course of the earliest generations the following psychological situations arose: (a) A certain compulsory situation, i. e. the necessity of living upon the same substratum, united the neighbors which at first were hostile; (b) a comparative freedom of motion diminished the probability of too frequent conflicts; (c) common advantages with respect to nesting conditions and food entered into play; (d) the occurrence of a comparatively similar nest odor (the odor of the *Juglans*) lessened the violence of the conflicts and assisted the adjustment to the common conditions of life.

All these factors were operative upon the ants dwelling on the *Juglans*, and they became fixed (by means of inheritance) in the course of time until finally they effected the friendly communityship which we find today.

II. CONCERNING VARIATION IN THE LEPTOTHORAX TUBERUM R. AFFINIS AND FORMICA RUFA.

1. *Leptothorax tuber. r. aff. M.*—In my examination of the *Leptothorax* specimens found at Neuenstadt I was struck by the singular circumstance that I found *very few examples of pure race.* Among one hundred colonies, fifteen at most corresponded precisely to the accepted descriptions and illustrations. They varied particularly in respect to the form and length of the epinotal spines. I was not able to determine whether these variations were caused originally by in-breeding, cross-breeding, or special segregation.

2. *Formica Rufa L.*—The rufa inhabitants of colony 12 in my *Formocozenus* enclosure (vide Biol. Zentrbl.) exhibited the constant characteristic of an indented scale. The workers and the females differed from the normal *rufa* type by means of this variation. The cause of the said variation appears to be in-breeding.

III. TENACITY OF LIFE IN A LEPTOTHORAX COLONY.

I kept a medium sized colony of *Leptothorax tub. of aff.* in a test tube which I found near Geneva, May 15, 1917, until February 10, 1918, without giving them any sort of food. The workers did not begin to die until the middle of December, 1917, while the queen finally passed away on February 9, 1918.

IV. IN-BREEDING IN THE LEPTOTHORAX.

In small colonies of ants in-breeding must be regarded as a necessary fakultative mode of procreation. As a matter of pure theory this sort of copulation must necessarily be the most frequent. Forel expresses himself to this effect with respect to the *Leptothorax* as far back as 1874. I myself found among the *Leptothorax tub. of aff.* a great number of both males and females in the same colony at the same time. This view is supported, furthermore, by the abundance of Pleo-metrosis (1-300).

V. PLEO-METROSIS IN THE FORMICA PRATENSIS DE GEER.

While examining on October 5, 1917 a *Formica pratensis* ant hill for *Formicoxenus nitidulus* (colony No. 20) I found 12 females and among these there was 1 ☿ *rufa*, 8 ☿☿ *rufa-pratensis*, and 3 ☿☿ pure *pratensis*. It is hard to tell whether this was occasioned by secondary adoption of the strange females or whether it was due, perhaps, to mendelian ants. Both possibilities seem not improbable.

Electrical Conductivity of Acids and Bases in Aqueous Solutions

J. C. Ghosh continues previous work [see Abs. 881 (1918)]. The abnormally high mobility of the hydrogen and hydroxyl ions in aqueous solutions has been explained on the assumption that electricity is partly carried by the ordinary process of convection and partly propagated through water molecules undergoing alternate dissociation and recombination. The apparently high activity-coefficients of strong acids and bases in aqueous solutions have also been traced to this cause. A modified Oswald equation $(ax)^2/(1-x)V = K$, based on the consideration that only free ions have the capacity of regenerating undissociated molecules, has been developed for weaker electrolytes, where the degree of dissociation is less than unity. It has been shown that this equation becomes identical with Oswald's dilution law in the case of very weak electrolytes, where α is always very nearly equal to one, and also gives very concordant values for the equilibrium constant in the case of "transition electrolytes" where Ostwald's equation is not applicable.—*Sci. Abstr.*

The System Iron-Copper

R. Ruer and F. Goerens continued the work of Ruer and Fick [*Sci. Abstr.*, 366 (1915)]. As before, samples of 25 gm. of each of the two metals were quickly heated up in a porcelain tube (Tammann furnace) and then stirred with the quartz sheath of the thermocouple, a current of nitrogen being maintained through the tube. The materials were electrolytic copper (99.95% Cu) and a very pure iron with 0.002% C.; in the further thermal investigation electrolytic iron was used. There was always a separation of the melt into two layers, the upper rich in iron, the lower rich in copper; the separation was sharply defined, especially at high temperatures. The compositions of those two layers changed with the temperature, there being 82.31 and 90.6% Cu in the heavier layer at 1,440° and 1,569° C. respectively. The lower layer showed more tendency to undercooling than the upper. The extreme percentages mentioned seem to be incompatible with the melting curve, according to which the temperature-fall corresponding to these concentrations should be 200 deg. It is definitely shown that the middle portion of the freezing curve is not horizontal; on solidifying the system, Fe-Cu behaves therefore like a system of three or more substances. Yet impurities were not taken up by the metals during the treatment, and the analyses for the nitrogen percentages in the metals always yielded values below 0.03%. It is hence suggested that a molecular complex, slow in formation and decomposition, plays the part of a third substance; but the authors acknowledge that they have no further support for this apparent contradiction of the phase rule. The transformation temperature of the γ–β change in iron was lowered by the addition of copper from 906° to 823°; the β–α change was lowered by 1% Cu from 769° to 759°. From electric conductivity measurements it was concluded that iron can only contain 1% Cu in solid solution at ordinary temperature. This result is contradicted, however, by the study of the structure; copper can dissolve 1 or 2% Fe. The magnetic permeability changes occurred in copper of 95% at the same temperature as in copper of 50% and less.—*Sci Abstr.*

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[1] It still remains to be determined what influence is exerted by temperature upon these alliances.

[2] In connection with this see the writings upon this subject of Wasmann, Brun, Vichneyer, Wheeler, Emery, Kutter, etc., most of which were published in the Biol. Zentralbl. The following psychological observations are based upon the adoption experiments of these investigators, especially those of the myrmecologists Wasmann, Brun, and Kutter.

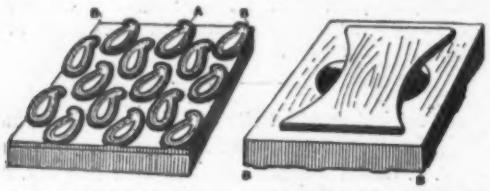
Printing Silks*

Old Hand-Block Printing Contrasted With Present Expensive Power Machines

(Photographs and electrotypes by courtesy of *American Silk Journal*)

It is said that there has been such surprising progress made in the printing of silks in this country within the last decade that the great achievements attained are perhaps not known outside of those who are actually engaged in the production of print silks. It may be doubted if even they have paused long enough to give serious and analytical consideration to those characteristics which mark the upward tread of the industry and its products.

It is not so very long ago that the bulk of our printed silks came to us from France. Comparing the silks we were then printing with the Lyons product, buyers would wisely declare that our printers had a long way to go before they could expect to attain anything approaching the perfection of the French printers. It is another story today. The American fabric printers



Wood printing block. A, raised pattern; BB, guide pins. On right, back view.

have forged ahead at such a pace that working now for the most critical and exacting clientele in the world —the American silk manufacturers— they are turning out a class of work that gives gratifying satisfaction. It is the very excellence of this work that is today a factor in creating the large demand that exists for printed silks. Both fabric designer and printer possess greater versatility than ever before, and with the greater range of possibilities for their talents they are accomplishing things now that not so very long ago looked impossible.

What has opened up these new opportunities for print silks? Have they come through the development of the art side of the industry? Were the first striking achievements obtained during the time when the craze for Cubist, Futurist, Post-Impressionistic and other wild and seemingly incongrous design inspirations and color schemes entered into fabric fashions? Did the printing of those design and color thoughts upon silks furnish the incentive for some of the recent achievements in complicated design and color work?

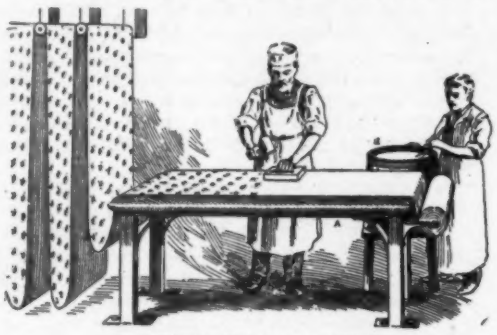
Some credit is undoubtedly due to the fabric stylers who, foreseeing through their intuitive knowledge of the fashions the needs of the market, have been of material assistance to the designer and the printer. Viewed from the mechanical side of the industry, credit must also go to the machine builders for the perfect printing machinery they have supplied, thereby making possible the execution of the wonderful print fabrics of today. It would, therefore, appear that all of these factors have been working in an apparent harmony of effort, and that there has resulted the present high achievement in print silks which has placed them in a foremost position in the field of fashion and in the market.

In the light of the present success of print silks it is possible to offer a number of explanations as to why, in former years, they did not hold an equally strong and prominent position in the fashions of the seasons. One of the popular explanations is that smoother, clearer and more effective designs can now be printed than the weaver with his indispensable "stepping" can weave. The colors are equally prominent, and the product is much less costly. Besides print silks seem to fit into a wider range of utilitarian uses in the mode than woven pattern silks. From time to time as brocades have come into vogue, they have been taken up for just a brief while only to be turned back among the discards, because elderly women felt there was nothing youthful about them, and the younger set considered them too old looking. It is not so with print silks. They possess a dash, style and smartness that is all their own. Their designs and colors are adaptable to every fashionable requirement.

As a pattern producer, the printing method has some advantages over the weaving. The thickness of the thread limits the changes of shade in weaving: delicate mixtures of color are therefore impossible. Figuring on fabrics would thus be crude and conventional if no other method of coloring were known. It is here that the textile printer surpasses; he can lay on what colors he pleases; his work is like painting, imitative of all the shades and colors of nature.

We take up an average printed silk and ask ourselves what are the characteristics which give it a market value? In the first place, we discern that it has a use, or a utility value, maybe as a dress fabric, as a lining for a garment, as decorative hangings, or furniture covers. This "use value" lies in the fabric itself, and its degree is mainly determined by the quality of the material—the counts of the yarn and the nature of the weaving. When reaching the printer's hands it is usually a plain fabric possessing in more or less degree the utility value expected of it.

The natural colors of textile fibers are seldom uniform and more rarely pleasing to the eye. In the textile trades they significantly name fabrics in the natural color greys—that indeterminate shade between light and dark, a mixture of colors which do not blend. If the natural greys were one uniform shade, they might be useful, but they are yellowish greys, bluish, reddish, greenish and blackish greys, changing and shading in all degrees. Uniformity of color, either plain or patterned, has always been regarded as a necessary quality in cloths; the random variations of nature are generally offensive. To obtain uniform white, we bleach; for a single and uniform color, we dye; for colored patterns, we either weave with yarns dyed different colors, or print.

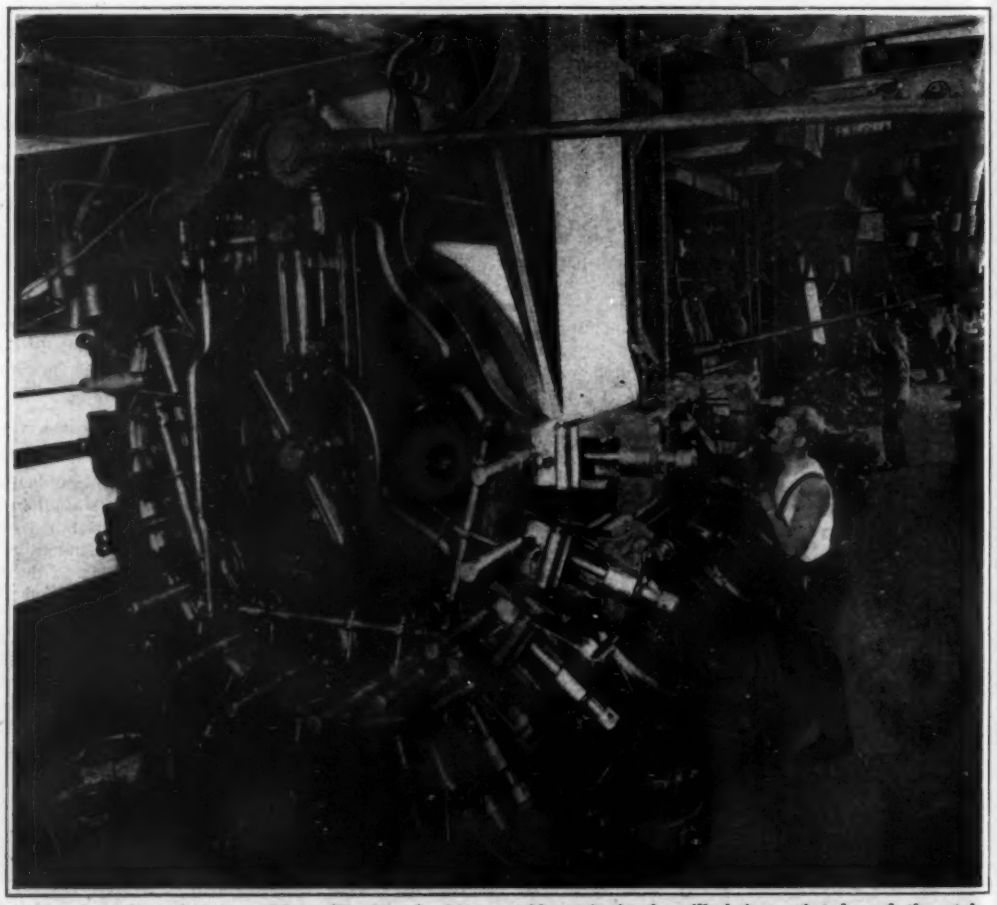


Handblock Printer at Work.
A, table; B, drum or sieve on which the boy spreads the color; C, the block.

From the standpoint of use, there is no reason why these monotonous greys should not be placed upon the market in that state; and so they might, were it not for the human objection to monotony and the desire for something more than the satisfaction of material wants alone. This something we might call a sense of value —sense of sight—it is the addition of this sight value to the fabric which is the work of the printer and gives to the product its distinctive character. Thus we get in the finished article two clearly defined values lumped together specifying two equally defined human demands, one utilitarian, the other emotional, so that it may be said the complete printed fabric possesses a body and a soul. The fabric printer's unique vocation is that of giving a soul to the fabric. How often for financial profit this soul is nothing but a spook may be left for individual printers to decide.

In the matter of utility of color it is interesting to know that, apart from its distinct contribution to the total value, this addition often increases the utility value, as for instance, when the fabrics are covered with decorations, the design and colors of which reduce the necessity for washing to the minimum, or when the design harmonizes with the use to which the fabric is put. Given two designs printed upon the same quality of fabric, the deciding factor in their sale will accord with the merits of the designs printed upon them. Commercially, merit is conceded a design in accordance with its degree of success in ministering to the emotions of the purchaser, therefore, it follows that the printer whose designs reflect familiarity with the customs—religion, politics and intellect of the peoples catered for—has an advantage over one whose knowledge is only empirical.

The process of printing silk as it is now done is a complicated one requiring elaborate machines which are capable of printing a large number of colors at one time and distributing them evenly with uniform registration. This complicated process of machine printing can best be understood through an explanation of the earlier process of hand blocked printing, for basically there is not much difference between blocked printing by hand and roller printing by machine. It is in the dyes and processes of fixing the colors that differences appear.



A 10-color silk printing machine. The broad white outside strip is the silk being printed, and the strip running over rollers is the carrying blanket.

*From *Amer. Silk Journal* (New York).

HAND PRINTING.

The hand printer is an artist, and like all artists, he uses a few simple tools. The principal furniture of his printing room is a table from 15 to 20 feet long and from 30 inches to 50 inches wide. Within what may be called the printing section of his table, a smooth slab of stone, or slate is evenly set and over it spread a fine felt to give the surface elasticity. At the top end of the table there is a pair of brackets upon which the cloth roller hangs, the function of which is to run the printed cloth smoothly on to the range of drying rods beyond.

Hand printing is done by large blocks of wood upon which the pattern is either cut out in relief or formed by copper wire fixed on the surface. The blocks are made of a size to contain a full section of the patterned design.

Various color-holders have been devised, but the oldest and most common is the sieve or drum. This is a broad hoop over which oil-cloth is tightly stretched. Upon the smooth surface of the drum the color is laid, and a woolen cloth is stretched over it, the color penetrating evenly and lightly through the cloth. The drum generally rests upon an elastic base of some sort, the handiest being a tub of paste which may happen to be out of use. With the beam of cloth rolled upon it staying at the head of the table, and the cloth drawn over the printing slab to the full length of the table, the printer takes his first block, lets it softly rest upon the color drum, to take on the color, and then lays it evenly upon the cloth, face downwards. Giving the bottom of the block a firm tap, the printer lifts it, leaving a clear impression of the pattern upon the surface of the fabric.

The design may be simple, and carried on one block, or it may be large and complex, both in size and variety of colors, and fill many blocks. To guide the printer in laying-on, there are small points on the block which leave marks on the cloth, showing the space which has been covered. When laying-one the next block the printer is guided by the marks.

While the printer works, his boy assistant must keep the drums well supplied with the thick color, which has, of course, already been prepared. After the section on the printing slab has been fully colored, the cloth is shifted along toward the end of the table and another length of the cloth unrolled.

A supreme drawback to the printing of textiles by hand is the cost. For example, to print a piece of cloth 30 yards long by 36 inches wide, with an ordinary size of block, and in one color alone, takes no fewer than 672 applications. When the design is in four colors, the printer must print approximately 3,000 times. This takes days, and a skilled block printer's time is of some value.

MACHINE PRINTING.

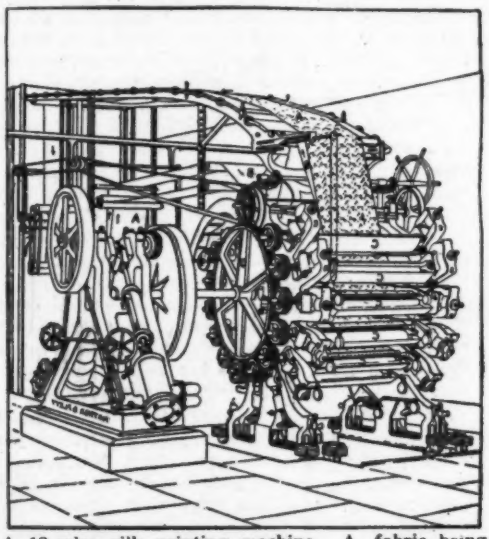
The first attempts at machinery were in the direction of making the machines imitate the block printer, and a few very ingenious contrivances were devised of which the French Perrotine is the best and most remarkable. Somewhere about 1785 a cylinder printing machine was invented and has since been very much improved and developed by machine builders supplying the printing trade, as our cuts show.

The modern silk printing machine consists of a heavy iron frame, a large impression cylinder supported by bearings on which its shaft extends out to the driving wheel and is surrounded on the lower sides by as many printing rollers or cylinders as there are colors to be printed. Each roller is engraved with the part of the pattern which its color is intended to print. The axles of the printing roller revolve in bearings on the outer ends of the side frames. It

Close-up views of various silk-printing machines.

is obvious that the problem involved in the supply of different colors to the rollers presents difficulties. A roller, however, is not geared to the cylinder by itself; it is merely the center of a complete set of appliances. There is the color box, with color supply roller, called the "furnisher," a pair of horizontal knives one above and the other below the roller and named "lint doctor" and "color doctor" respectively, and spring screws or weighted levers which alternately press the roller upon the central impression cylinder and take it away.

Above the impression cylinder, the frame forms a double guide, one for the blanket and backing, the other for the piece being printed, the former always circulating in an endless round, while the latter passes out on



A 12-color silk printing machine. A, fabric being printed. B, carrying blanket. C, printing apparatus containing pattern roller, color duct, color roller, lint and color doctor. D, spur driving printing appliances.

to the drying cylinder adjoining as soon as printed. To ease the impression, the central cylinder is usually covered with a padding of woolen cloth, or a fine india-rubber lining protected by a layer of cloth.

To begin with the working of the machine, the colors of the design to be printed are first separated, and the parts of the patterns so colored are engraved on each single roller. All the rollers are the same size and cover the same area, and represent a complete pattern if taken together.

When the rollers have been engraved, the printer prepares his colors, and fills each color box with its proper color. He must see that the color roller is clean the engraved roller the straight steel blade called the color doctor is set by screws just close enough to the roller to scrape away the pigment from the flat surface and press the color into the engraved parts. On the inner side a similar blade, the lint doctor, is carefully adjusted so that the blade will take away any threads or other adhesions on the printing roller after it has pressed upon the cloth.

Impression and register are the next objects of the printer's attention. He must see that the rollers are adjusted to the point at which they will print exactly on the space of the cloth designed. As the colors are all parts of one design, and print close to each other, the adjustment is delicate. Regulation of impression is another rather difficult duty. The colors must not be pressed through the cloth, nor impressed so lightly as to appear faint. Balance of weights and levers, usually secured by the makers of the machine, may not be difficult, but some judgment is called for in regulating the rollers to the impression desired.

The piece to be printed and the blankets and backing cloth having been smoothly regulated, the machines can be put in gear. The whole of the driving power is concentrated on the center shaft, the axle, so to say of the pressure cylinder. Upon this runs the large crown wheel which gears into the small pinion wheels on the ends of the roller shafts. As the pressure cylinder revolves, therefore, all the printing rollers with color-furnishing rollers also revolve. The great cylinder carries around the piece of cloth and the engraved rollers impress themselves upon it one after the other, and it passes out, a completely printed piece.

Several features of this operation demand careful attention. Because of the corrosive action of the colors upon the doctor blades as well as upon the copper of the engraved rollers, the decomposed metal reacts upon the colors, and blunts the edges of the blades. Constant attention on the part of the printer is needed, if the mischief is not to become serious.

Another point to be noted is the tendency of the colors first printed to "cast" upon those printed later. Frequently dark grounds are first printed, and when these carry over into the lighter colors a blurred design is the result. If possible, the light shades should always be printed before the darker colors. But continual care, frequent cleaning of the rollers, and strict measure of color are the best preventives. For all its name the "doctor" alone cannot cure all troubles and man must take a hand.

The steam style is the usual method of silk printing. Mordant and coloring matters are mixed together and printed upon the cloth, and the steam acts in various ways upon the substances, but uniformly developing the colors and fixing the mordants. It needs to be clearly understood that different materials in the steam style demand different treatment; sometimes the variation is so great as almost to constitute a style. For this reason, the silk printer differentiates strongly between the classes and kinds of colors used, viz., the natural coloring matters, the coal-tar colors, and the minerals or pigments. It can hardly be said that the last class is of any importance, because pigment dulls the luster of the silk, and therefore is not popular.

Where the goods are tentered or smoothed out after washing.

Rolling the finished printed fabrics on boards ready for the market.

Bouyancy of Crystals

By adapting Stokes' formula for the rate of fall of raindrops through air to the case of spheres of ice rising through water, the author finds that such a sphere of 0.2 mm. diam. may be expected to rise at 0.1 cm. per sec. An ice crystal of the same volume would rise even more slowly, which accounts for the fact that the fine ice crystals found in Northern Canadian rivers show but little effect of buoyancy.—H. T. BARNES, in *Roy. Soc. Canada.*

Recent Progress in Aerial Photography—II*

Remarkable Improvements During War and Applications To Peace-Time Needs

By L.-P. Clerc

[Concluded from Scientific American Supplement, August 30, 1919, No. 2278, P. 138]

The very low temperature which prevails at great heights, often lower than 30°C., is the cause of many difficulties, such as the unequal contraction of the various materials employed, the thickening or solidification of many lubricating oils, the hardening of the leather or rubber used in the friction controls, the condensation and freezing of water in the mechanism of the shutters or plate-holders. The Germans avoided the resultant light leaks by fitting the interior of the apparatus with an electric heater whose current came from the wireless generator. A variation in the focal distance of the lens and the contraction of the body of the apparatus tend to interfere with the focussing especially in lenses of great focal length. In spite of heavy garments and interlined gloves the movements of the observer are greatly hampered, if not entirely paralyzed, and he loses his customary delicacy of touch and this leads to a rough handling of the instruments which even the most stoutly built are sometimes unable to resist. During a descent the glass lenses warm up less rapidly than the metal parts, thereby causing the moisture of the air to condense on the glass so as to form an almost entirely opaque screen unless the surface of the glass has been previously covered with an anti-fog substance such as glycerine soap.

Since difficulties increase so greatly as the altitude increases it may be asked why it is required to take pictures at such great heights? The reply is that in times of war, because of the great improvement in anti-aerial defense, it has been found necessary to fly at a constantly increasing altitude over points of interest, and long-range reconnoitering was found possible only with avions capable of flying normally at a height of over 5,000 m. (16,250 ft.). Even in times of peace it is necessary to fly very high when topographical applications of the views are to be made, since the lower the altitude the greater the divergence between the map and the photograph where the terrain is very irregular. (See the map on page 138.)

As a general rule good results cannot be uniformly obtained except by an observer accustomed to flying, trained in map reading and skilled in handling the apparatus employed, and when both he and his pilot have studied the itinerary to be followed in its minutest details. In particular is it highly desirable, and even of primary importance, that the observer should keep in mind that the plates should not be brought out into the light either with the purpose of verifying their quality or the mode of loading the plate-holder or to tell the exposed from the non-exposed plates.

Reading and Interpretation of Photographs.

Either quite apart from ordinary topographical arts, or used in conjuction with these, aerial photography, and vertical photography in particular, played an important part during the war and proved an inexhaustible mine of information for those skilled in its interpretation. The necessary study is much facilitated in all cases by a stereoscopic examination and by the comparison of recent photographs with collections of those made previously at the same point. The first complete studies of aerial photographs were made in Artois early in 1915 by Gen. Arnoux, who, completing his observations by information gathered at the front by his miners and sappers, drew diagrams on copy paper [calques du cadastre] of the detailed plan of the German organizations of Carency, of Ablain Saint Nazaire, and of Neuville Saint Vaast.

The minuteness of the details thus revealed, which had escaped a great many observers caused General Arnoux to be regarded as a bit of a visionary until the taking of these towns by our troops confirmed the flawless logic and strict correctness of his deductions. The Champagne and Artois attacks in September, 1915, were the occasion of new verifications on the spot, and the comparison of aerial and terrestrial photographs of the same organizations furnished valuable documents for study. Since that time the interpretation of aerial photographs has been looked upon by the various general staffs as the most fruitful source of information with regard to the defensive organization and the plans of offense of the enemy. This method has been extensively employed.

But it is evident that to bear fruit this method of interpretation requires a certain amount of preliminary training as well as patient and methodical labor.

A good interpreter must constantly bear it in mind that however logical his deductions may be they must usually be regarded as mere hypotheses until verified by information from some other source, such as terrestrial observations, route marking by signals for the ear or the eye, patrols, the questioning of prisoners, counter-spying, etc.

Without going into detail here as to the methods employed in interpretation—a theme which might occupy a whole volume—we may mention the following among the features revealed by aerial photographs: batteries, emplacements of machine guns and Minenwerfer, the entries to ventilating shafts of dug-outs, observation posts, telephone systems, trenches and their accessory defenses, communication trenches, railroads, dumps, parks, springs or pools of water, bivouacs and cantonments, etc.

Aerial Stereoscopy.

When two photographs are taken with a suitable interval between, 500 meters (1,650 ft.) for example, in the case of vertical photographs taken at an altitude of 4,000 m. (1,300 ft.) with a lens having a focal length of 0.52 m., it is possible to constitute, by means of the portion common to each photograph, a stereoscopic couple whose examinations will reveal with startling clearness all the alterations and reliefs of the terrain, which will appear to be exaggerated, in fact. Stereoscopy makes it possible to unmask the cleverest camouflage and to bring into evidence details which would otherwise remain entirely concealed. This art is of value not only in the case of vertical exposures, but also yields valuable information with regard to the alterations of the terrain throughout an extensive region when one takes panoramic photographs with a nearly horizontal exposure; but the interval between the two exposures is equal to about a hundred meters, requiring a lapse of only a few seconds of time. It thus becomes practically impossible to employ but a single camera, as in the case of vertical exposures, since time would be lacking for the necessary shifting of the plates; this difficulty is evaded by coupling two instruments and making successive releases at the desired interval. (See page 136.)

There can be no question of a simultaneous release of the twin instruments as in the case of ordinary stereoscopy since all perception of relief disappears beyond a certain distance; the smaller the interval between the lenses the shorter this distance is, being about 20 meters when the lenses are at normal pupillary interval.

Application to Topography.

However valuable an aerial photograph may be as a cartographic document it must not be confounded with a map, even when taken upon an absolutely horizontal plate, which it is practically impossible to do; for the more elevated portions of the terrain are reproduced on a larger scale and slide along their base while departing from the center of the photograph (in consequence of the conical projection); therefore if we suppose, for example, a meridian to be indicated on the ground upon a rather irregular terrain, this line, which appears on the map as a straight line would appear in the photograph as an undulating line. Since these undulations would be of opposite phase in two views taken on either side the meridian line a superposition of the views would exhibit gaps (the highest points of the line of junction) and overlaps (the lowest points of the same line).

The distortion of the images due to the use of the focal plane shutter and to the atmospheric refraction suffered by oblique rays, the lack of certainty at the moment of exposure with regard to the position, and altitude of the avion, and the location on the ground of the base of the station, the uncertainty with regard to the value of the principal distance(i. e. the distance of the optical center from the photographic plate), and with regard to the position of the principal point (the foot of the perpendicular erected between the optical center and the plate) in apparatus which have not been constructed specially for precise topographical surveying,—all these are just so many possible sources of error which make it extremely difficult if not entirely impossible to execute an exact large-scale map by aerial photography alone.

On the other hand this art when *directed solely by topographers* would be the most perfect of all means for the "filling in" of the outline [canvas] made on the ground by the ordinary processes of topography, or better still, by metro-photography invented in France by A. Laussedat and since employed by all the great official topographic services except those of France.

Aerial photography is especially indicated for the remaking of the map of France on the scale of 1:80,000. * * * Finally, under suitable precautions the method might be entrusted, even unaided, with the making of small-scale maps (e. g. 1:200,000) of regions inaccessible at present, but which may later be penetrated by a net of triangulations. This network would permit the same photographic records to be again used for a larger scale map.

Various Applications.

Besides these tactical and topographical applications aerial photography lends itself to numerous commercial uses. It may be used to advantage in advertising, e. g. to give a bird's-eye-view of a manufacturing plant; or for the preparation of various illustrated publications such as series of picturesque views, albums, illustrated postal cards, illustrations of guide books, geographies, etc. The method would also facilitate architectural studies, since the plan of a monumental structure could be drawn with ease and great precision from a large-scale aerial photograph.

In closing we may record a very interesting application of aerial photography that has been actually tried out by a distinguished architect. It consists in photosensitizing the surface of a relief plan and then projecting upon it photographically the picture of the corresponding terrain from aerial photographs. The relief plan thereby loses its schematic appearances and becomes a living image of the surface.

Low-Voltage Arcs in Metallic Vapors

J. C. McLennan describes experiments by Harmer and Kemp on lines similar to those of Millikan and Hebb [Abs. 778 and 779 (1917)]. The experiments show that increasing the temperature of the incandescent kathode lowers the voltage necessary to produce arcs in the vapors of Hg, Zn, and Cd. With limed Pt kathodes arcing voltages were not obtained as low as with incandescent tungsten filaments. With highly heated incandescent kathodes it was found that with vapor of low density the arcing potentials were generally high. When the density of the vapor was gradually increased the arcing potential fell and reached a minimum value at a certain density of the vapor. When the density of the vapor was still further increased the values of the arcing potentials rose again. The voltages necessary to maintain the arcs were found to be less than those which had to be applied to strike the arc. With Hg it was found possible to strike arcs with arcing potentials as low as 4.75 volts, and to maintain them with an applied p.d. of 2.84 volts. With Cd vapor arcs were struck with impact voltages of 5 volts, and maintained with p.d.'s of 2 volts. To obtain these low-arcing voltages it was necessary to use intensely hot kathodes and a copious supply of highly heated metallic vapor. In many experiments when voltages near the minimum ones were applied a certain interval of time elapsed between the application of the p.d. and the appearance of the arc. With moderately heated incandescent kathodes and a moderate supply of vapor the arcing voltages for Hg, Zn, and Cd are given by the quantum relation $Ve = h\nu$, where ν is the frequency of the shortest wavelength of the $\nu = (1.5, S) - (m, P)$ series. With Cd vapor it was found possible to set up two types of arc in the vapor, the one being faint and the other brilliant. The line spectrum of the two types appeared to be the same in character, but different in intensity. Additions to the applied field of not more than a volt generally sufficed to turn the faint into the brilliant type, with which a continuous white-light spectrum was superimposed on the line spectrum. Irregularities in the experimental results were in a measure removed when the metal being vaporised was electrically connected to the positive terminal of the discharge tube.—*Sci. Abstr.*

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*Translated for the Scientific American Supplement, from *La Science et la Vie.*

Light and Organisms*

Orienting Effects of Monochromatic Light on Fucus Spores and Rhyzoids

By Annie May Hurd, University, California

ONE of the most striking of the biological phenomena resulting from the action of light on organisms is the orientation of the first cleavage plane of germinating spores by unilateral illumination. Whenever such illumination is sufficiently intense the first cross wall forms perpendicular to the direction of the incident light. This phenomenon has been demonstrated in Equisetum, Puccinia, Fucus and other algae [4, 8, 9, 10, 11] together with the fact that the cell on the shaded side of the spore becomes the rhizoidal cell irrespective of gravity. Thus in these and related forms the polarity of the plant is established by the direction of light stimuli.

The power of light waves to so orient the plant is, without doubt, the power to orient the spindle of the first dividing nucleus. The mechanics of such reactions may long remain unknown; but we have a suggestive and possibly the ultimate explanation in Child's[2] metabolic gradient theory. He has demonstrated in many marine plants and in some of the lower animals the existence of the so-called "axial gradients." By an axial gradient is meant the decreasing rate of metabolic processes from the apical to the basal end. We may suppose that such a gradient is produced within a germinating spore whenever there is sufficient difference in the amount of light energy received on two opposite sides to produce the requisite difference in the rate of the oxidation processes along the line of direction of illumination. If Child's supposition is correct, the cell on the shaded side of the spore becomes the rhizoidal cell by virtue of the fact that the least rapid rate of the oxidation reactions along the gradient determines the basal end, the most rapid the apical end, of the organism.

The purpose of the present investigation was to study the power of pure monochromatic lights to establish the polarity of the germinating spores of *Fucus inflatus*, and also to answer several questions concerning the negative phototropism of the young rhizoids; viz., the determination of the exact wave lengths responsible for the phenomenon; the relative importance of the quality and quantity factors in the illumination or the role of intensity of illumination apart from the kind of light; and whether all effective monochromatic lights produce the same result as white light.

To obtain the monochromatic light, seven Wratten filter screens were used, each transmitting a narrow range of wave lengths but altogether embracing the whole of the visible spectrum. The wave lengths to which each screen was transparent were determined by testing the light transmitted by each with a direct-vision spectroscope with a wave length scale attached. These screens were then fitted as windows in the ends of boxes painted black on the inside. Culture dishes were made by cementing together microscope slides, so that the light entering the boxes through the screens fell on a flat side of the dish and thus entered the water normally with a minimum loss from reflection and refraction.

The electric arc was used as the source of light wherever possible because it gives all the desired wave lengths, with the result that the whole set of screens could be used in the same exposure, insuring for all the boxes identical conditions of temperature and duration of illumination.

The spectroscopic analysis of the light transmitted by the screens gave the exact wave lengths which would act on the cultures behind them. The next step was to devise a means of making the intensities of the lights acting in each box equal so as to eliminate that most important, and hitherto largely overlooked, factor in light reactions. This done, variations in results obtained behind different screens might safely be attributed to differences in the quality of the stimulus. There have been several methods devised by which the relative intensities of monochromatic lights can be measured and made equal.[1, 3, 5, 6, 7] But all of these involve special apparatus not available for use in this investigation; so a simpler method was devised whereby the relative intensities of the lights transmitted by the Wratten filter-screens were measured by means of a thermopile and galvanometer and made equal by varying the distances of the dark boxes from the electric arc such that at these distances the deflections of the galvanometer, when the thermopile was exposed in turn to the light behind each filter screen, were equal. This distance was also measured with a piece of white glass as a filter screen which represented the removal of the control culture from the arc. The instruments used in this energy calibration were a Hilger thermopile and a d'Arsonval galvanometer.

It seems necessary on account of the questions which have been raised during the course of this work, to state here that the thermopile is equally sensitive to the energy of the red and of the violet ends of the spectrum, and is, therefore, an accurate measure of the total amount of light acting behind each color screen. The difference between heat and light is only a matter of wave length. The thermopile measures light in terms of the electric current produced by the difference in temperature of the exposed and unexposed junctions; but it does so by virtue of the fact that the energy of whatever vibrations fall upon it, be they long and therefore heating in their physiological effect, or short and therefore perceived as light, is converted into heat energy upon being absorbed by the exposed junction of the thermopile. In other words, the light of the blue end of the spectrum produces an electromotive force much less than that of the infra-red but no less measurable.

Once these distances from the arc, at which the intensities of the light in each box are equal, are determined, the quantity of light energy can be varied by multiplying or dividing all the distances by the same multiple and the intensities in all will still remain equal to each other. By means of a photometer the actual amount of light acting in each box can then be determined by measuring the intensity in candle meters behind the white glass control at the proper distance from the arc. Then from the law of inverse squares, viz., that the intensity of light per unit surface varies inversely as the square of the distance from the source, the absolute intensity at any distance from the arc can be computed. So a Sharpe-Millar photometer was used to measure the intensity of the naked arc at the distance of the white light control. But it was then necessary to correct the measurements so obtained for the absorption of light by the glass of the filters. This so-called absorption coefficient was obtained by measuring with a Lummer Brodhum photometer the intensity of a light both with and without a screen of clear glass equal in thickness to that of the filters. It was found that glass 1.5 mm. thick absorbed 12% of the light falling upon it. Therefore to obtain the intensity of the light actually entering each dark box, it was necessary to take 88% of the reading given by the photometric measurement of the unscreened arc at the previously determined distance of the white light control.

The following table lists the colored screens used with the wave lengths they transmitted and the distances from the arc at which they were placed to make the intensity of light behind each equal to 1,800 meter candles. The lack of agreement between these values and the energy curve of the spectrum is due to the individual absorption of the filters and also to the fact that they do not all transmit the same number of wave lengths.

Table showing distances at which the intensities of light from an electric arc transmitted by Wratten light filters are equal

FILTER NUMBER	WAVE-LENGTHS IN ANGSTROMS	COLOR	DISTANCE FROM LIGHT	INTENSITY IN METER CANDLES
			cm.	
70	6600-7000	Red	320	1800
71	6200-6800	Red	275	1800
72	5900-6200	Orange	230	1800
73	5600-5900	Yellow	250	1800
74	5200-5600	Green	280	1800
75	4700-5200	Blue	250	1800
76	4000-4700	Violet	250	1800
Control	4000-7000	White	340	1800

To obtain the spores of *Fucus inflatus* for the experiments, the fruiting plants were collected at low tide, kept over night in damp newspapers, and the next morning were dried slightly by exposing them to the air for about half an hour. Then when the fruiting tips were submerged in sea water in the culture dishes, large numbers of eggs and sperms were extruded and settled to the bottom of the dish. After removing the piece of plant the culture dish was placed in one of the little racks made to fit in the dark boxes behind the filter screens. The illumination of the cultures was continued six to eight hours, this time having been found more than enough to cause the first cleavage plane to be permanently oriented regardless of subsequent illumination.

In the experiments for which the naked arc was the source of light, the heating effect was so great that the spores were killed very quickly. The mercury vapor lamp was next used to obtain wave lengths of the blue end of the spectrum and a 100-watt nitrogen filled Tungsten globe for the red. But as in the case of the electric arc, the Tungsten light killed the spores by the high temperature produced at the distances where it was necessary to place the cultures for a sufficiently intense illumination. With the mercury vapor lamp, however, positive results were secured. The wave lengths which were found to produce the orientation of the first cleavage plane such that all the first cross walls formed perpendicular to the direction of the incident rays, are those between 4000 and 5200 Angstrom units. Behind the two other filter screens used with the mercury vapor lamp and transmitting wave lengths of 5200 to 5900 Ångstrom units, the spores germinated as if in darkness with the orientations of the first cleavage planes following no rule, and the rhizoids extending in all directions. However, the intensities of the lights behind these color screens were not equal when the mercury lamp was used because the shorter blue wave lengths predominated to so great a degree and hence produced greater intensities.

With regard to the phototropism of the young rhizoids, it was found that very weak white light, too weak to orient the cleavage planes, would cause the growing tips to turn sharply away from the source of light. With the intensity of illumination behind all the color screens equal to 1800 meter candles, only the blue and violet lights produced the phototropism. The other wave lengths at this intensity had no effect, the young rhizoids continuing in the direction in which they had started just as did those of the control in darkness. However when a more intense illumination was secured by placing the boxes in direct sunlight, the rhizoids behind the green filter, in addition to those behind the blue and violet ones, showed the same negative phototropism. This and subsequent experiments would lead us to believe that both quantity and quality, or intensity and wave length, are determining factors in the power of light stimuli to produce phototropisms.

In every culture of *Fucus inflatus* whether germinated in darkness or in strong unilateral light a most striking orientation of the first cross-wall with reference to adjacent spores appears. Wherever a group of spores are lying within about 0.2 mm. of each other, the first cleavage plane is perpendicular to the direction of the center of the group. The cell toward the interior invariably becomes the rhizoidal cell. This phenomenon was reported by Rosenvinge[9] in other species of *Fucus* and in *Ascophyllum*. For want of a better term I have called it *group orientation*. A study of the phenomenon was made to determine the strength of this stimulus, compared to that of light, in its power to establish the orientation of the plant. It was at once very evident that for the most spores the former stimulation is stronger when the spores are within a short distance of each other—0.2 mm. or often more—but beyond this distance, the chemical stimulus becomes too weak and only the light is able to determine the polarity of the plant. Only the comparatively isolated spores therefore show the orientation to light with the sources of illumination used here.

The phenomenon is very conspicuous in groups of 2, 3 or 4 eggs as well as in masses of 50 or 100. In these large groups it is made evident by the invariable rule that no rhizoid ever extends outward from a group. When two spores are within the distance through which the stimulus is effective, the first cleavage planes of the two are parallel and the rhizoids grow towards each other and often meet tip to tip. The groups of 5 or 6 often make symmetrical star-like designs when the

(*Continued on page* 176)

* From *Proc. Nat'l. Acad. Sci.* (Cambridge, Mass.)

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[9] Rosenvinge, M. L. K., *Revue Gen. Bot.*, 1, 1889 (125-135).

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Gathering Chicle Gum for American Gum Chewers

Collecting, Preparing and Shipping Chicle Gum for the United States

MANY of our readers will recall "the good old days" when the summer spent among the aromatic spruce and pine forests of our old northeastern states introduced us as boys to that primitive food substitute of the half-starved and thirsty hunter, spruce gum. Obeying that primitive instinct of a nervous race, to keep working at something with our teeth, we chewed splinters and grass stems until a friend showed that delightful ball of pink gum he had been working on for a week, and offered to show us where he got it. In our innocence we let him set us at work on a piece of pine resin and finally learned by bitter, doubly bitter experience that there is at least one important difference between the resins of the pine and the spruce (*Abies nigra*). Probably the Red Indian was the first to teach the Europeans this difference. In boyhood days we did not mind a preliminary half-hour of bitter but certainly healthy chewing for at last we secured from the real spruce resin a splendid aromatic "chew." Some who never went to the woods themselves after this old-fashioned "spruce gum," may recall seeing the crude gum exposed in bulk for sale in the stores of that period.

Spruce gum however, had another drawback beside its initially bitter flavor, viz., it deteriorated with steady prolonged use, became harder and brittle and finally had to be discarded in order that our severely aching jaws might rest from labors they were never intended to perform so continuously. Other gums were also developed, such as those of the sweet-gum, the tamarack, and the cherry, also mineral waxes as paraffin, and vegetable derivatives like beeswax. Today, however, nearly all these have given way before the virtues of the elastic chicle gum from the naseberry (*Achras sapota*) a tree of Central and tropical South America resembling the caoutchouc tree (*Hevea caoutchouc*).

The first step in the manufacture of chicle gum is the wounding of the tree which is done in much the same way as for collecting latex. Spiral intersecting grooves are cut in the bark and cambium, care being taken not to cut too deeply so that the tree may not die but continue at least half alive. The workman who taps or cuts the trees is called a "chiclero" and our frontispiece (p. 161) shows such an one in British Honduras climbing a tree with the aid of a rope loop, and probably freshening the cuts to increase the flow of sap. The fluid sap runs down the diagonals, oxydizing slightly on its way, and is finally caught or collected in a bag hung at the exit of the lowest incision. When full the bags are collected and carried to a central where the contents are spread out and allowed to oxydize still further. The slow evaporation is then hastened by placing the sap in kettles or crude ovens and boiling until the water is pretty well all driven off. During the process the sap is kept stirred and tested as to concentration by boys with long stirring rods.

When boiled down the product is melted up, certain flavors and colors added and the pasty mass which much resembles bread dough is kneaded into loaves or rather more solid blocks. These blocks are then assembled into bundles wrapped in native cloth and carried by man, beast or native canoe to the harbor towns. Our third view shows the wharves at Belize, British Honduras, where the bundles of block chicle are loaded into barges for transfer to the ocean freighters lying off shore ready to carry the half-finished materials to United States factories.

Tropical and South America sent to the United States 50,400 hundredweight of chicle in 1906; in 1910 this had increased to 60,600 hundredweight while Canada the same year also imported 15,000 hundredweight, making the total imports of 1910 75,600 hundredweight valued at $3,112,000. Most of the chicle we import comes from Yucatan and British Honduras, being shipped from the port of Belize. It is estimated that there are now (1918-19) about 75,000,000 consumers which has created an industry now rated at $45,000,000 in this country.

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Boiling down the chicle sap to drive off water. The result is a dough-like mass.

Electric Driving in Cement Mills

ELECTRIC motor driving is particularly applicable to cement mills because continuity of operation is essential to efficient production. A description is given of the process of cement manufacture, and of the apparatus and sizes of motor employed. The El Paso plant of the Southwestern Portland Cement Co. is described; this has a capacity of 1,500 barrels per 24 hours. Limestone and shale are quarried on the site. The power equipment includes two 750 kva. 440 v., 3 ph. turbo-alternators. An electrically driven compressor serves rock drills. With few exceptions the machines in the plant are driven individually, by induction motors ranging from 10 to 440 h.p.—*Electrical Review.*

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The kneaded, flavored and colored "dough" becomes blocks which are bundled for shipment. Here a barge-load of bundles in Belize harbor is ready to be loaded on an ocean-going steamer. Note also the native dug-out canoe.

The Finger-print System in the Far East

IN Henri Cordier's new edition of Sir Henry Yule's "Cathay and the Way Thither" (1914) I came across the following note by the editor (p. 123, vol. iii.):

"With regard to the finger-print system in the Far East we shall make the following remarks: In *Nature* of October 28, 1880 (p. 605), Mr. Henry Faulds, writing from Tokyo, drew the attention to the use made by Japanese of finger-prints, and came to the conclusion 'that the Chinese criminals from early times have been made to give the impressions of their fingers, just as we make ours yield their photographs.' In the same periodical (November 22, 1894, p. 77), Sir W. J. Herschel claimed to have been the first to exhibit the system of finger-prints on board the P. & O. S.S. *Mongolia* in February, 1877. This system he had found in 1858 and communicated to Mr. Galton, who made use of it in his 'Finger-Prints' (1892); hence the discovery of the system was ascribed to Sir W. Herschel in a Parliamentary Blue Book. Sir W. Herschel added in his letter that, to the best of his knowledge, the assertion that the use of finger-marks in this way was originally invented by the Chinese was wholly unproved. Sir W. Herschel was entirely wrong; Mr. Faulds (*ibid.*, October 4, 1894, p. 548) protested against the claim of Sir W. Herschel, and finally a Japanese gentleman, Kumagusus Minakata (*ibid.*, December 27, 1894, p. 199), proved the case for the Japanese and the Chinese. None of these writers quoted the passage of Rashid-ud-din, which is a peremptory proof of the antiquity of the use of finger-prints by the Chinese."

The passage referred to in Rashid-ud-din is quoted by Yule on the same page in the following words:

"It is usual in Cathay, when any contract is entered into, for the outline of the fingers of the parties to be traced upon the document. For experience shows that no two individuals have fingers precisely alike. The hand of the contracting party is set upon the back of the paper containing the deed, and lines are then traced round his fingers up to the knuckles, in order that if ever one of them should deny his obligation this tracing may be compared with his fingers, and he may thus be convicted." (Sir H. Yule's translation from the French translation of the Arabic text by Klaproth, in *Journ. As.* for 1833 (?), pp. 335-58 and 447-70.)

It seems to me that the description of the process by Rashid-ud-din, so accurate and explicit, can in no way apply to the method of identification by finger-prints. There is no indication of a preliminary blackening of the hand, or of an impress left on the paper. It is definitely said that the process consists in the drawing of an *outline* of the extremities of the fingers "up to the knuckles" while the hand is set on the sheet of paper.

Either Rashid-ud-din has entirely misunderstood the description given to him by Pûlad Chingsang, the envoy of the Grand Khan to Tabriz, from whom he appears to have gathered most of his information regarding the Mogul Empire (*ibid.*, p. 111), or we have here the description of a process of identification hitherto unknown.

Anybody who will take the trouble to trace the outline of the outstretched fingers of the hands of different individuals will easily gather how different are the figures obtained in regard to the absolute and relative length of the fingers, to their relative distance from one another, to the angle made by the axis of the thumb with the axis of the index, and so on.

Whether these differences correspond with a distinctly characteristic drawing for each individual person, so as to make the process a real method of personal identification, I am not prepared to say, but the matter might be worthy of further investigation.—FILIPPO DE FILIPPI, in *Nature.*

Copying Fingerprints—I

New Methods for "Lifting" or Transferring Fingerprints on Objects by Prepared Paper or Foils

By Robert de Résillac-Rosé

LATENT fingerprints, i. e. impressions that are formed by the fatty or oily excretion of the outer skin whenever the fingers come in contact with an object and that are made visible by the powdering process or other methods, were first observed in France in 1891 by Dr. Forgeot.[1]

According to the color of the touched object, these impressions can be made visible by sprinkling them sparingly with any of the following powders: Graphite, bone-black, pine-soot (lamp blacking), indigo, aluminum, antimony sulfide, chalk, tannin, sea-foam powder, anianthus (French chalk), powdered blueing, kaoline (pipe clay), gypsum (plaster of Paris), sulfuric-acid baryta, manganese-bioxide, marble powder, a number of colored bronze powders, such as argentorat (silver-bronze), red lead, carmine, iron powder (ferrum alcoholisatum), lycopodium with carmine (as used by Dr. Roscher, Hamburg), lycopodium with scarlet red (90% lycopodium and 10% scarlet red), used by Dr. Stockis, Liège, and similar substances.

The most satisfactory results are obtained with flocculent graphite and indigo powders for impressions on glass and white paper and other light-colored objects, and with chalk, sea-foam, kaolin and French chalk for impressions on dark backgrounds.

Every transportable object with latent impressions found at the place of crime is taken to Police Headquarters, where these impressions are photographed and enlarged from three to six diameters, and whereby the identity of such discovered impressions with those of a suspected individual is positively established by comparing their points or characteristics in their patterns.

PHOTOGRAPHY OF FINGERPRINTS.

All latent impressions on objects that are not transportable, such as on walls, doors, large mirrors, window panes and similar objects, are made visible by the powdering process and are photographed.

Impressions of bloody fingers or fingers stained with ink, soot, printer's ink, paint, etc., on light colored surfaces, such as paper, white painted doors and walls, porcelain, etc., can be photographed either in daylight or under artificial light in the usual way by using ordinary normal-sensitive plates.

More difficult, however, is the photographic reproduction of such impressions on dark colored backgrounds, such as dark smooth wooden objects, furniture, weapons, etc. In this case the powdering process has to be applied; the impressions are first sprinkled over with a white powder (aluminum or kaolin) and the camera has to be planted in such a position that the right shadow will be thrown, i. e. in an angular position from the object.

Latent impressions on glass articles are powdered most effectively with graphite and are photographed in the usual way. When impressions on glass bottles are powdered with a white powder, the bottle should be filled with some black fluid to obtain good photographs.

Fingerprints on white porcelain are sprinkled with black or red powders and must be photographed in strong oblique light. Impressions discovered on white porcelain with blue designs are dusted with red powder and must be photographed on ordinary normal-sensitive plates under oblique light (see Fig. 1).

Special care must be taken with photographic reproductions of latent fingerprints on glossy, polished, smooth metallic objects (candlesticks, door handles, etc.); in these cases the powders must be selected according to the color and material of the object. Aluminum is used on yellow metals (brass, gold, etc.), while red powder is sprinkled on white metallic objects (nickel, silver, etc.). The aluminum powder has the effect that the ridge patterns appear in silver-bright, shining lines; when the impression is exposed to a strong oblique light, it appears on the ground glass plate in bright white lines and shows, when the photograph has been taken with ordinary plates, in strong contrast to the nearly black appearing brass or gold background. In the case of red-powdered impressions on white metal, the red impression appears black on the photographic plate and the bright metal background shows white. Latent impressions on glossy leather, polished wood, shoes, dark-painted strong boxes, etc., should be exclusively sprinkled with kaolin (pipe clay) and are photographed with ordinary plates in oblique light.

Figure 2 represents the photographic reproduction of a kaolin-powdered impression on a green leather wallet.

Photographic reproductions of latent impressions on various colored papers have to be treated in a different manner, according to the color of the paper.

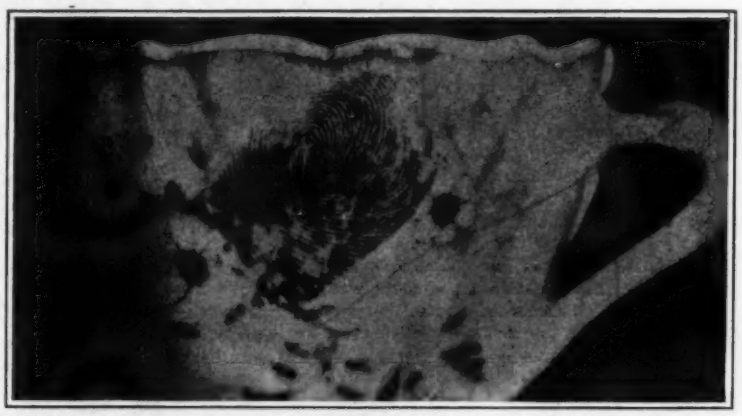

Fig. 1.—Fingerprints on white porcelain with blue designs are dusted with red powder and photographed under oblique light on normal-sensitive plates.

White paper is sprinkled with flocculent graphite or powdered indigo. Blue paper is dusted with red powder. The impressions are photographed with ordinary, normal-sensitive plates under oblique light.

Light-red paper with bluish background is sprinkled with dark-red powder, and light-red paper with yellowish background with graphite. Orange-yellow paper is sprinkled with blue powder; impressions on such paper must be photographed with color-sensitive plates under oblique light and using a green filter.

Impressions on dark tints of red, green, yellow and blue papers and on black paper, are powdered with white powder and are photographed with ordinary plates under oblique light.

Impressions in dust and half-dry substances, for instance, paint, wax, sealing wax, dough, clay, etc., are also photographed with ordinary plates under very oblique light.

All these photographs can be taken under different

Fig. 2.—Photograph of a kaolin-powdered imprint on a green leather wallet.

light sources, but the electric light, especially when impressions are photographed under oblique light, is the most efficient on account of its intensity.

Photographs of latent impressions on light backgrounds, powdered with red, black or blue powders, and those of white-sprinkled impressions on dark backgrounds, can be made in ordinary daylight.

A firm in Rochester has solved the problem of a practical and efficient camera for producing accurate photographic prints of latent impressions, which do not require any expert knowledge of photography, with their "Fingerprint Camera." Its small size, 11¾ x 6 x 6 inches, makes it exceptionally convenient for general use, and especially when used in locations inaccessible to apparatus previously employed, which apparatus required the use of the tripod, as well as of means often difficult to procure, for artificially illuminating the object.

But even with this camera it is sometimes extremely difficult to obtain satisfactory and distinct reproductions of impressions left unintentionally at the place of crime. In using ordinary cameras, the light conditions may be so unfavorable that the exposure has to be unduly prolonged and that it is difficult to time it properly, and in consequence faulty reproductions are inevitable. Long exposures become blurred and appear double when photographs are taken in buildings whose floors are shaken by vibration (machinery). The distance of the object from the lens may be too little or too great. The impression may be at a place where it is impossible to set up a camera. Photographs of impressions on mirrored surfaces are indistinct on account of the simultaneous exposure of this mirrored surface itself and present a double-line picture. In photographic reproductions of impressions on arched, inflexed and curved objects with shining surfaces, the photographs show bright spots that are impossible to avoid and are extremely annoying. The background on which an impression is discovered, may be of polychromatic nature, as for instance on painted strong-boxes, marble, colored paints, wood veins, etc., by which the ridge picture of the impression becomes on the photograph either completely or partly interrupted.

When the photographic reproduction of a latent impression shows such defects, it is extremely difficult to make a comparison regarding the identity of this impression with the original fingerprints of the suspected individual, if not entirely impossible.

MECHANICAL "LIFTING" OR TRANSFERS OF FINGERPRINTS.

To overcome these defects and obstacles, different methods have been devised, by which a discovered latent fingerprint is "lifted" from the object and transferred on specially prepared papers or foils, after the impression has been powdered.

These new methods have the great advantage that any person, without using a photographic apparatus, is enabled to take easily and reliably any fingerprint discovered at the place of crime in the shortest possible time, and to transmit such obtained imprints without regard to time and distance in unchanged condition to a photographic room, where the positives of these impressions are printed for identification purposes.

BRAZILIAN EXPERIMENTS IN "LIFTING."

The first experiments for "lifting" latent fingerprints from objects were made by Dr. Dubois, Brazil, who described his new method in "Journal do Commercio, October 20, 1899," which he named "Papel Registrador" ("registering paper"). He uses for the transfer of impressions found at the place of crime, a fluid composed by the simultaneous melting of 50 grams of wax and 50 grams of paraffine, and adding 20 drops of glycerine and stirring the mixture well. Paperstrips of any desired length are dipped in this solution, are dried in a few moments in the air and are ready for use. His method, however, has the following disadvantages: After the paper has been dipped in the solution, its surface shows at certain places small rough spots in the form of little craters and prevents the transfer of latent impressions from arched and uneven objects. The paper has to be warmed before it can be used.

A similar method is recommended by another Brazilian, Dr. Manuel Viotti, which he describes in "Identificaçno e Filiaçno, 1910."

BELGIAN METHODS.

The next method is by Dr. Stockis, Liège (Belgium), the famous police laboratorist, and dates from 1910. He uses in his "nouvelle méthode de relevé par transfert des empreintes et des taches" ("A new method for transferring fingerprints and other imprints") photographic copy paper, covered with a layer of glycerine. In case of transfer of bloody or colored impressions, the paper is immersed in a solution of sodium hypophosphate (NaH_2PO_2) and is pressed on the discovered fingerprint. Air bubbles between the paper and the object are removed by pressing slightly on the paper and stroking it at such places. The transferred impressions show clearly in every detail as a colored picture on a white background. When white fingerprints have to be taken, for instance, from flour, dust,

[1] For a brief history of the use of fingerprints for identification, see "Encyclopedia Britannica," latest edition, article "Fingerprints."

etc., he uses a black paper, covered with a layer of glycerine, which previously has been exposed to the light.

GERMAN METHODS.

Birnstengel in Dresden, Germany, uses a gelatine paper that has to be treated first in the same manner as the Stockis paper; he employs bromide or silver chloride paper. After the latent impression has been lifted, the paper with the transferred fingerprint is pressed on a thin cardboard, which is covered with a thin layer of ordinary paste. When the moisture has completely disappeared, the paper with the gelatine (bromide or silver chloride) layer peels off by itself and the true ridge picture of the impression can be seen on the cardboard, protected by the gelatine layer. This method, however, has the disadvantage that it takes some hours to obtain good pictures.

The methods of Dr. Stockis and Birnstengel make it possible to secure and transfer the following impressions:

(1) Impressions of fingers, hands, bare feet and shoe-covered feet that were covered at certain places with powdered dry substances, such as coal-dust, brick-dust, gypsum, street dust, etc. After the imprint is detached, a colored design of the ridge patterns of the fingers or bare feet and a perfect reproduction of the shoe design appear on the white background of the paper.

(2) Impressions of fingers, hands and bare feet on smooth and dusty surfaces, such as furniture, floors, etc., which in most cases are visible to the naked eye with the help of a strong slanting light falling on these objects. When these methods are used, a black dust-free pattern design is obtained on the transfer paper on a gray dust-covered background.

(3) Impressions of fingers, hands and feet, which were covered with some fluid, for instance, blood. A colored picture appears on the transfer paper. When indications point to the fact that the bloody impression will not detach itself easily from the background on account of being too old or too much dried up, the adhesive propensity of the paper can be increased by placing it for some hours in a solution of 50% water and 5% glycerine.

(4) Colored drawings, ink and pencil writings and marks on untransportable objects, whose photography at the place of crime is impossible, can also be transferred on these papers.

R. Kockel, of the Criminal-Medicinal Department of the University of Leipsic, Germany, uses very flexible celluloid foils, such as the Eastman roll films, bathes them in warm water and hangs them up for drying after their light-exposed layer has been removed. Pieces of any desired length are placed on a drawing board, are fastened down at the edges with thumb screws and are evenly brushed over by means of a broad, soft brush with the still warm solution of

white gelatine..... 15 grams
distilled water .....100 cubic centimeter
muriatic acid..... 0.3 gram

The whole is melted in a water bath and 30 cubic centimeters of the purest glycerine are added. The solution is filled in bottles and may be used for a long time. The thin celluloid foils, painted over with the glycerine solution, are left lying for 24 hours in a horizontal position, are cut into strips of any desired length and are covered with thin celluloid protective plates.

Kockel recommends as the most suitable powder for making latent fingerprints visible the argenton powder (manufactured by Weigel & Zeh, Dresden, Germany).

Joseph Rubner of Munich (Bavaria) uses a gelatine paper which he prepares with a solution of 50% glycerine and 50% ordinary mucilage. The mixture is applied to the gelatine paper by means of a soft sponge, and the whole paper leaf is then dried. As powder he recommends very fine aluminum.

Rubner's method was first used by the Munich Police in 1913. Meanwhile he has improved considerably his method by substituting a translucent gummy paper (that does not require any protective plates) of 1/10 millimeter thickness, consisting of two layers—an inflexible lower one of subdued color and an upper gelatine layer. This leaf is pressed on the powdered fingerprint without being moistened; in case of the formation of air bubbles, these are removed by stroking the paper carefully at such places; if the air bubbles are very small they do not disturb the clearness of the impression in the least. The back, or lower side of the paper, on which the "exact" picture of the fingerprint appears, is not gummy or shining, but of subdued color, this having the great advantage to divert rays of light, so that weak impressions appear stronger against the light. This layer is also washable and takes writing. After the fingerprint has been transferred, the imprint is pasted on a thin gelatine leaf as protection, and the transferred fingerprint and the gelatine paper unite so completely and thoroughly after a short time that both seem to be of one piece, which remains always flexible and unbreakable. The transferred impression can be compared at once with other fingerprints for identification purposes.

The paper shows the papillary lines (ridges) of the fingerprint (powdered with aluminum), in white on a black background; in pasting the paper on a glass plate and holding it in a slanting position above a white background, the ridges of the pattern appear in black on white.

One of the greatest advantages of this leaf is that it *completely replaces the photographic plate.* The manifolding is done by pasting the leaf directly on the light-sensitive paper and to expose it to the light. The imprint appears then, which is of the greatest importance, in its *natural* condition, showing the "exact" ridge pattern in white on a black background.

If an imprint in black on white is desired, the light-sensitive paper layer is placed on the subdued color-layer of the paper, resulting in the "reverse" impression in black on a white background.

Such transferred latent impressions on Rubner's gelatine leaf are used in court cases as mutual complement for the to-be-compared fingerprints.

This leaf can also be used for taking impressions of writing and marks on doors, walls, etc., and for taking the fingerprints of dead persons. The fingers of the corpse are rubbed in with printer's ink, the gelatine leaf is pressed upon them, is removed, the number of the different fingers is noted on the subdued color layer, and the taken fingerprints are pasted on the fingerprint card.

On account of its great efficiency, Rubner's method has been adopted not only by the Munich Police, but all over Bavaria and other German countries. Every policeman, every fingerprint station, is supplied with these gelatine leaves, and many valuable place-of-crime impressions are forwarded from all parts of the country to the Central Fingerprint Department at Munich.

AUSTRIAN EXPERIMENTS.

Rudolf Schneider's method had its first trial in 1911, when the Vienna Police began to employ the inventor's new method, which is used now throughout the Austrian-Hungarian country.

His method is as follows: The fingerprints found at the place of crime are powdered and then "lifted" from the object by means of a foil, which has been patented. This lifting is done in such a manner that the foil, after its protection-plate has been removed, is pressed lightly on the discovered impression, by which the latter transplants itself from the object to the foil. The foil with the transferred impression is then removed from the object, is covered again with its protection plate, and the impression on the foil can be photographed at any time.

The impressions transferred to these foils are exceedingly durable and very distinct; they appear in white on a deep-black background, and for this reason they are especially adapted for photographing and identification purposes. These foils can be used a number of times on any object and material, such as wood, oil and varnish paints, bone, glass, metal, marble, etc., without the least damage to the foils. On account of the flexibility of the foils it is posible to transfer on them, complete and in natural size, not only the impressions from level, but also from convex and concave surfaces and angular objects, and to obtain photographs of the lifted impressions, which are complete and true to nature.

These foils are also used in Brazil; the Rio de Janeiro Police Department purchased a few years ago great quantities of them and several hundred pounds of Schneider's powder.

Figures 3 and 4 omitted are photographic reproductions of latent impressions "lifted" with the Schneider foils. Fig. 3 shows under (a) a small watering can; (b) represents its photogram taken in the old way, which shows on account of bright light effects and the great roundness of the object an interrupted and distorted pattern picture; (c) represents the transferred fingerprint on the foil; and on (d) the photogram of the foil shows the fingerprint in its complete, natural form.

Figure 4 shows under a. a small multi-colored piece of shining and polished marble; b. (its photogram taken in the old way) presents on account of the polychromatic and shining background a very indistinct ridge picture; c. is the lifted fingerprint on the foil; and d. is the photograph of the foil with the distinct pattern picture.

AMERICAN EXPERIMENTS.

The only experiment in America with lifted latent impressions has been made by O. W. Bottorff, Superintendent of the Fresno County Bureau of Identification, who uses a clear photo film (easily cleared by washing in warm water), cuts this film into strips of a width needed for print of a finger, coats the film at one end (with space sufficient for print) with rubber cement (such as is used for vulcanizing tires) and an equal amount of gasoline. This coating is made even by holding the film at different angles in order to allow the coating to spread out uniformly over the surface; the surplus is shaken off, the film is allowed to dry until nearly hard; the drying may be accelerated by holding the film before an electric fan. The discovered imprint is sparingly sprinkled with either Chemist's gray, dragon's blood, aluminum powder, or gold dust, and the residue is brushed off with a soft, dry camel's hair brush. The coated side of the film is placed over the impression and pressed firmly upon it to prevent slipping, is rubbed evenly over back or top with a soft cloth to secure even contact; the film is lifted from surface and the finger print is secured. Care must be exercised for noting which side of the film was down to avoid confusion in using transfer for classification and comparison.

Physical Characteristics of X-ray Fluorescent Intensifying Screens

THE experiments described by M. B. Hodgson are introductory to a general study of fluorescence produced by X-rays. Spectrograms of the fluorescences excited in various materials, in particular calcium tungstate, have been made under varying conditions. The fluorescence is shown to be primarily dependent on the following factors: (1) selective absorption of the elements of the crystalline compound in the intensifying screen, (2) the frequency of the existing radiation, and (3) the crystal structure of the particular calcium tungstate used. The author suggests that the X-ray analysis of the crystal structure of calcium tungstate will probably throw a great deal of light on the subject.

It has been shown that in a photograph made from a screen system, about 20% of the exposure is due to the absorbed energy of the direct rays, the remaining 80% being supplied by the screen fluorescence. In trying to shorten exposures by this method, the author has tried using the characteristic radiation from metal screens. Silver, Cu, Pb, W, and Pt have been used, Ag and Pt proving most effective.—*Sci. Abstr.*

Crystalloluminescence

FROM a survey of the literature, and experiments on the crystalloluminescence and triboluminescence of arsenic trioxide and potassium sulphate, H. B. Weiser concludes that triboluminescence, like crystalloluminescence, is caused by chemical action. In the case of substances which show both triboluminescence and crystalloluminescence, the chemical reaction and hence the color of the luminescence are identical. The identity of the crystalloluminescence and triboluminescence of arsenic trioxide and of potassium sulphate has been shown photographically. The color of the luminescence is specific, depending on the chemical reaction by which it is caused. A large number of substances exhibit the property of triboluminescence, but relatively few show crystalloluminescence. All the well-defined cases of the latter are to be found among the simple inorganic salts. In the case of inorganic substances, the crystalloluminescence is due to the rapid re-formation of molecules broken up by the process of electrolytic dissociation; triboluminescence of the same substances is due to the rapid re-formation of molecules broken up by the violent disruption of crystals. All crystalloluminescent substances show the property of triboluminescence, but the reverse is not true. That all triboluminescent substances are not also crystalloluminescent is due to the fact that sufficient breaking up or disarrangement of the molecules (other than by ionisation in solution) is usually accomplished only by the grinding or crushing of crystals. Due to the conditions attending their formation, a state of strain may exist in certain newly formed crystals that will disappear with time. If outside force is applied to such crystals before the internal forces have become adjusted, the combined effect may result in a particularly violent disruption of the crystal with a correspondingly marked molecular decomposition and consequent triboluminescence. The intensity of triboluminescence varies widely in different substances. Two causes contribute to this, namely, the comparative forces necessary to break up the molecule in different cases, and the magnitude of the conversion factor for light in the luminescent reaction.—*Sci. Abstr.*

The Sense of Stability and Balance in the Air

In the monograph on the above subject recently added to the valuable series of special reports published by the Medical Research Committee[1] Dr. Henry Head, F.R.S., records investigations made upon both normal and abnormal subjects from the point of view of flying. Of particular interest is the section dealing with the sensations experienced by normal persons in heavier-than-air-machines. It is shown that conscious stability and comfort in the air depend primarily on the normal response of three groups of sense organs—namely, the vestibular appratus, the eyes (including the eye muscles), and the proprio-ceptive system with its endings in muscles, tendons, and joints. Defective response from any one of these afferent end-organs disturbs the sense of equilibrium in the air, and leads to actions that affect the stability of the aeroplane. The report indicates that undue importance has hitherto been attached by many experts to the vestibular apparatus. It has become increasingly apparent to those connected with flying that although the sense of stability is dependent upon the integrity of the vestibular apparatus, the importance of the afferent impulses streaming in from eyes and the proprio-ceptive system must not be overlooked. An expert pilot finds it impossible to fly a machine with his eyes bandaged, and under these circumstances derives most of his information from cutaneous sensation and from the nerve endings in muscles, tendons, and joints. It is well known, as in the case of the recent Atlantic flight by Alcock and Brown, that when the sense of vision is cut off the pilot loses himself in space, and may emerge from a fog or cloud with his machine at a steep angle or even upside down. Under these circumstances he is dependent almost entirely upon instrumental guidance for flying, and it may be that in future some instrument, such as Sir Horace Darwin's "Turn Indicator," will be fitted to machines and be largely relied upon to give the pilot information in respect of his position to the earth.

Taking seriatim the chief points of interest brought out by Dr. Head: While flying an aeroplane an otherwise healthy man may suffer from disorders of vestibular and visual sensibility due to temporary causes. Such are giddiness through inability to regulate the tension in the middle ear with sufficient ease during a rapid descent, and defective visual orientation due to the development of heterophoria owing to disturbance in function of the eye muscles. Dr. Head shows that in some men, otherwise normal, rotatory stimuli produce a more powerful reaction than in the majority of their fellows. They become giddy easily. As children they could not swing with pleasure, and some of them were habitually sick in the train. Such persons are not suffering from a pathological condition; their disability arises from the fact that sensory impulses from the semi-circular canals are not checked and controlled to the same extent as in the majority of healthy individuals. Consequently, when exposed to disturbances of equilibrium to which a normal man would adapt himself unconsciously, they suffer from discomfort, become giddy, and may even vomit in the air. Many who were giddy when first exposed to acrobatic evolutions succeed in conquering this disability. They learn to fly with ease, and the acquisition of this new facility is associated with control of the primary afferent impulses from the auditory and visual apparatus. Any condition which produces diminished control by the highest faculties over the activity of lower centers is liable, however, to lead to regression to the earlier mode of reaction. All healthy men can be affected if the intensity of the rotatory stimulus is pushed up to sufficiently high degree. This may occur either from the fact that the head is held in some unusual position, as, for example, when looking upwards during spinning, or the actual rotation may be mechanically increased in rapidity. In some cases the reaction to such excessive stimulation takes the form of giddiness, with or without nausea; in others it is associated with that withdrawal of consciousness known as "fainting." When a man is made giddy he is in a state of confusion with regard to his relations in space. In the preliminary stages of "fainting" his horizon is restricted and the world around disappears. Both states, pushed to the limits of endurance, end in unconsciousness.

Complete adaptation to disturbances of equilibrium in the air is associated with automatic control of the afferent and efferent activities of lower levels of the central nervous system. The normal pilot merely desires that his machine shall behave in a certain manner and the evolution occurs. This acquired facility can be disturbed by any condition which leads to diminished control. Just as a golfer can be "put off his game" by some physiological or mental state, so the aviator may lose his capacity to fly in consequence of conditions that vary so widely as a gastro-intestinal attack or domestic anxiety. Exhaustion, insomnia, the distress of war flying, anxiety, or fear can all lead to defective afferent and efferent control. Efficient automatic response is no longer possible, and the pilot begins to fly badly and to make bad landings. This loss of control over the activity of lower levels may be manifested, however, not only in bad management of the machine, but also in some dangerous reaction, such as "giddiness" or "fainting" in the air. When this abnormal reaction assumes the form of giddiness and nausea it is found in most cases that the patient has suffered from some discomfort when he first went into the air. Inquiry will usually reveal also that he was unable to swing with pleasure as a child, and that he tended to be sick when travelling by train. In this group rotatory impulses, when released from control, manifested their influence in giddiness, usually accompanied by nausea. When the reaction takes the form of "fainting" it is generally found that the subjects enjoyed their first flight and could swing with pleasure. Their resistance to vertiginous impressions was high and no excessive giddiness resulted, but they could induce the effects of shock with undue facility. Dr. Head has performed signal service in drawing attention to the importance of regression in the airman, and showing that this may be produced by mechanical, physiological, or psychical causes.

In dealing with the tests for estimating the sense of balance used by the Examining Board of the Air Force Dr. Head criticizes them adversely, since the results of the tests employed have, as is so commonly done, been entered frequently under heads such as "nervous debility," "muscle sense," and "vestibular stability" rather than under a heading indicating the actual tests employed. In his opinion the tests do not afford information in regard to the conditions they were designed to investigate. It is shown that the tests are of value in revealing the existence of some abnormal functional state, but are not otherwise an indication of ability to fly. Dr. Head, however, is not correct in his belief that the results of the tests employed have not been entered in detail on the admission forms of candidates for the Royal Air Force, and in this way he has, no doubt quite unintentionally, done an injustice to the authorities concerned in his criticism of their records. We understand that many thousands of results of tests have been so entered, although, as indicated above, possibly under a wrong heading. A future study of these data will serve as a control to the experimental conclusions arrived at by Dr. Head as a result of the employment of the same tests. In conclusion, Dr. Head is to be congratulated on the way in which he has collected, described, and analyzed individual examples of various abnormal states that may make their appearance during flight. The paper is a stimulating and original contribution to the medical aspects of flying.—*The Lancet.*

[1]Medical Research Committee Special Report Series No. 28. *Reports of the Air Medical Investigation Committee,* "The Sense of Stability and Balance in the Air."

Light Sense*

The whole subject of light sense is indifferently understood. When we pass from bright sunlight to a dimly lighted room we can see nothing until our eyes have become adapted to the dark. This adaptation is supposed to depend principally upon some change in the relation between the bacillary layer of the retina and the adjoining pigment, and takes three-quarters of an hour or more to become complete, and in the second place upon the dilation of the pupil, which occurs very rapidly. It is a curious fact that the fovea is physiologically night-blind, for a fully dark-adapted or scotopic eye is found to have a central scotoma; round the fovea is a ring that is most sensitive to light, and beyond this ring the light sense fades gradually towards the periphery. Again, the scotopic eye is color blind, but on the admission of more light the first colors recognized are yellow and blue, after them the greens, and, finally, the reds. On a dark night the grass looks grey, while the color of yellow flowers may still be distinguished, but the red geraniums appear black. As there are no rods in the fovea, though they are found in increasing numbers towards the periphery, it will be seen that there are some good *prima facie* grounds for considering the rods as the percipient elements for light sense and the cones for color sense.

*For a study on the "Performance of Night-glasses" we can recommend Bulletin No. 3, by L. C. Martin, D.I.C., &c., published for the Department of Science and Industrial Research by H.M. Stationery Office.

The light sense may be tested in two different ways: (1) Light difference (L.D.): The estimation of the smallest difference of brightness that can be appreciated between two sources of nearly equal luminosity; and (2) light minimum (L.M.): the estimation of the smallest quantity of light that can be recognized in a faintly illuminated patch on a black background. Ophthalmologists find that L.D. is most affected in diseases of the optic nerve, but that L.M. is chiefly diminished in glaucoma and in diseases of the retina and choroid. It is found that practice increases the L.D. sensibility enormously, and, indeed, the results of L.D. and L.M. tests vary so greatly in different individuals that no definite value can be assigned as the standard of either. When Professor E. M. Barnard (Yerkes Observatory, U.S.A.) found that he could detect a wire at such a distance that its diameter subtended an angle of only 0.44″ (i. e., less than half a second) at the nodal point of his eye, it is a proof of his extraordinary sensibility to light difference; it is no test of his form sense. The minimum visible for form sense is 53.1″, and is usually taken to be 1′. Many tests that are supposed to deal with the form sense are really only testing L.D. Even the dot test cards that are so frequently used fall under suspicion for this reason. In practice this may not be very serious, as in many callings an adequate light sensibility is more important than a superior form sense. On a dark night most people have found that they see better without their spectacles than with them, as then they are relying upon their light sense and not upon their form sense, which is improved by increased definition. Every optical instrument entails some loss of light from absorption and from reflection at the surfaces of the glass; and yet, as is well known, telescopes enable one to see stars that are invisible to the naked eye, and night glasses are of invaluable use to the mariner. The principles underlying these two instruments are entirely different.

The apparent brightness of a surface in ordinary circumstances, if the size of the pupil remain constant, simply depends upon the intrinsic brightness of the surface. A piece of white paper 1 inch square at a distance of 4 feet is as bright as a piece 1 foot square. If, however, an object be so small that its image only falls on part of a bacillary element, unless it be exceedingly bright it may not succeed in stimulating this element. When faint stars are observed through a telescope their apparent size is not increased, for they still subtend an angle less than the minimum visible, but all the light which falls on the object glass may by a suitable eye-piece be concentrated on the observer's pupil, neglecting the light lost by transmission through the instrument. The action of the telescope is tantamount to increasing the area of the pupil to that of the object glass, and hence the brightness of the faint star is virtually increased. If, however, the object viewed subtend an angle (e. g., 10′) greater than the minimum visible, no optical instrument can increase its brightness per unit area. Yet, as is well known, in the dusk a night-glass enables objects to be seen that are invisible to the naked eye, although telescopes with a magnification of 20 or so will prevent objects being seen that can be dimly distinguished without it. Similarly, all microscopists have noted that when high eye-pieces are used the field becomes much darker. This is simply because the emergent beam of light from a high ocular is so thin that only part of the pupil is filled with light; indeed, the pupil receives far less light than when a lower eye-piece is used. Now one advantage of a Galilean binocular is that the section of the emergent beam is never less than that of the pupil and, consequently, no light is lost from this cause. But we have said that the brightness per unit area cannot be increased, how then can the visibility of an object in a dim light be increased by night-glasses? All workers agree that the minimum intrinsic brightness necessary for the perception of an object varies greatly with its size. It is clear, then, that night-glasses with a magnification of 4 or 6 will increase the visibility of objects in a dim light owing to their increased apparent size. We may at once conclude that as long as the section of the emergent beam is not less than the pupil of the observer's eye advantage will be gained by increasing the magnification; but if the sectional area of the emergent beam is less than that of the pupil the image may become even dimmer than the object when seen by the naked eye. Piper[1] has pointed out that in dark-adapted eyes the light sensibility is about twice as great with both eyes as with one, though in light-adapted eyes no such binocular summation takes place.—*The Lancet.*

[1]Ztschr. f. Psychol. u. Physiol. d. Sinnesorg., 1904, v. 37, p. 98.

Light and Organisms

(*Continued from page* 171)

rhizoids have grown and project beyond the group. The spores are more rarely affected in this way when the distance between them is over 0.3 mm. but the phenomenon is sometimes observed in spores as much as 0.5 mm. apart. Within a distance of 0.2 mm. there are practically no exceptions.

The relative sensitiveness of a spore towards light and towards this chemical (?) stimulus varies greatly for different spores. When cultures were placed in the window to get as strong a light stimulus as possible in order to determine at what distance from each other the eggs had to be not to show a greater sensitiveness towards the chemical stimulus than towards the light, it was found that this distance followed no rule, the spores showing the greatest individual differences. Of two spores lying within 0.3 mm. of each other one might be entirely oriented by the adjacent spore while the other, apparently like it, would show only the action of the light stimulus. In many cases two such spores would seem to show a resultant effect of the two stimuli so that both would be half turned towards each other with both rhizoidal cells showing a tendency to take a direction away from the light at the same resultant angle.

Rosenvinge ascribes this group orientation to a difference in the concentration of oxygen or of nutritive substances on the two sides of the spore. He thinks the rhizoid forms on the side toward the center of a group or towards another egg because the water on that side is less rich in the active substance than on the outer side as a result of their metabolism. Winkler[1] working with *Cystoseira barbata* found that a difference in oxygen concentration has no such effect. Apparently the phenomenon does not occur naturally in this species since his figure shows nothing but the effect of light. I have never seen a culture of *Fucus inflatus* with spores germinating so near each other, which showed only light orientation and not the group orientation. Almost invariably when the spores of this species germinate in such close proximity, light appears to have no power to establish the polarity of the plant.

The possibility that the group orientation is due to a polarity established by the position of the egg in the oogonium is suggested by finding many groups of eight lying just as they escaped from the oogonial sac and conspicuously oriented with respect to each other. The fact that groups of ten or of two are as regularly oriented, would refute the suggestion; but in order to prove that the phenomenon is the result of a stimulus acting after the eggs leave the oogonium, a group of them were transferred to a watch crystal and mixed with the point of a needle until their relative positions were entirely changed. But when they germinated the characteristic orientation with respect to each other was found to be without an exception.

The only apparent explanation of the group orientation is that of a diffusion gradient of some substance emanating from a growing spore, or of some substance being used up by it. A continuation of the investigation of this problem will be an attempt to discover a substance which can so affect the dividing nucleus of the egg cell that its unequal distribution on the sides of the cell will orient the axis of the spindle. The effect of bubbling carbon dioxide and oxygen through cultures should be tried as being the most probable factors involved.

The substance or condition originating in the activity of adjacent spores which has so powerful an effect in orienting the first cleavage plane and in determining which cell shall become the rhizoidal cell has no power to cause any chemotropism of the rhizoids after they are started. No rhizoid has been found to have its direction modified by the presence of other spores adjacent to it. In the absence of any light stimulus the rhizoids continue in the direction that they take originally from the spore.

[1]See note on page 171.

Effect of Wall Colors on Lighting Requirements

THE amount of illumination required in a room for a given intensity depends largely upon the amount of light absorbed by the walls and other surfaces. Dark surfaces absorb light and make for gloom and glare. Light surfaces throw a good proportion of the light back into a room and make for effective illumination. If the source of light is not changed, the effective illumination will vary with the reflection factors of the surfaces in the room. If, on the other hand, it is desired to maintain a fixed intensity of illumination in a room, then the amount of light to be supplied will vary inversely as the reflection factors, which are as follows:

	Per Cent.
Flat tone, white	79
Enameloid, white	80
Flat fone, pearl gray	63
Enameloid, French gray	39
Enameloid, gray	28
Flat tone, silvery gray and Caen stone, equal parts	56
Flat tone, silver gray	52
Flat tone, pale azure and buff stone, equal parts.	38
Flat tone, lichen gray	70
Flat tone, ivory white	76
Flat tone, ivory	72
Enameloid, ivory	64
Enameloid, primrose	67
Flat tone, Caen stone	72
Flat tone, ivory tan	58
Flat tone, cream	71
Flat tone, buff stone	46
Flat tone, buff	59
Enameloid, flesh	57
Flat tone, tan	37
Enameloid, tan	27
Flat tone, cocoanut brown	22
Flat tone, bright sage and ivory tan, equal parts.	47
Enameloid, satin green	56
Flat tone, bright sage	43
Flat tone, forest green	21
Enameloid, olive green	14
Enameloid, grass green	10
Flat tone, pale azure and white, equal parts	45
Flat tone, pale azure	36
Enameloid, sky blue	31
Enameloid, emerald green	29
Flat tone, shell pink	57
Enameloid, pink	51
Enameloid, cardinal red	27
Enameloid, wine	12

The percentages are the results of some tests conducted by the National Lamp Works of the General Electric Company with gas-filled tungsten-filament lamps. The figures are also fairly correct, however, with vacuum tungsten and "daylight" gas-filled lamps.

Royal Meteorological Society

Two interesting papers were presented to the Royal Meteorological Society of Great Britain at its monthly meeting on April 16, 1919. Mr. Alfred A. Barnes, F.F. Met.Soc., M.Inst.C.E., read a paper entitled "*Rainfall in England: The True Long Average as Deduced from Symmetry.*" It has been usual to assume that the average annual rainfall during any period of thirty-five years can be adopted for obtaining the "long-average" at any rain gauge, but the author considers that the fluctuations which occur between such averages for various thirty-five-year periods tend to show that the basis is somewhat uncertain. By an exhaustive analysis of the annual readings at 38 rain gauges in England during the sixty-two years 1856-1917, the author proves that variations of as much as 5 per cent. on each side of the mean are quite possible when dealing with successive thirty-five-year periods. From these same records it is then shown that far greater consistency in the value of the average can be obtained by taking periods symmetrical about the end of the year 1886. Both by means of tables and diagrams the author shows that that date is a very critical one in regard to rainfall in England, and that as a rule the years before that date were relatively far wetter than years subsequent to it. Hence the balancing of the earlier wet years by the later dry years establishes the principle of symmetry about that date, and it is shown that by this method the maximum departure from normal which results from taking each of the 15 long period symmetrical to the end of the year 1886 does not exceed 1 per cent. in the case of any of the 38 gauges which were examined.

Mr. C. E. P. Brooks, M.Sc., F.R.Met.Soc., also read a paper entitled "*The Secular Variation of Rainfall.*" In order to obtain a measure of the secular variation of rainfall during the past thirty to fifty years, correlation coefficients were worked out between the annual rainfall at each station and "time," the measure of the latter being the number of years before or after the middle year of the series. This was done for 162 stations distributed over the globe, and the results were charted on a map. This map shows that the greater part of the world is divided among a few definite regions of wide extent, in each of which the rainfall has been either increasing or decreasing. The most important area of increasing rainfall is temperature Eurasia (except the western seaboard); other areas are south-east South America and the south of Australia. Areas of decrease are the tropical regions as a whole, South Africa and the West Coast of Europe. It is noted that the number of sunspots and also of solar protuberances during the period in question have been decreasing. For a few stations records of longer period are dealt with, giving indications that the results obtained are due to a periodicity of upwards of fifty years.—*Engineering* (London).

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